1989

A computer program for pipe clamp analysis

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Order Number 1339625

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San Jose State University, 1989

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A COMPUTER PROGRAM FOR PIPE CLAMP ANALYSIS

A Thesis

Presented to

The Faculty of the Department of Civil Engineering

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

Jeffrey Edward Jones

December, 1989

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ABSTRACT

A COMPUTER PROGRAM FOR PIPE CLAMP ANALYSIS

by Jeffrey E. Jones

This thesis provides the engineer with a computer program, called NuClamp, that is able to generate the necessary finite element model and input to analyze most standard or non-standard pipe clamps.

NuClamp was developed to provide the user with a tool to perform the finite element analysis of a pipe clamp with minimal user input and training. This was accomplished by constructing an interface between the user and ANSYS (version 4.1) using a model building method that is commonly used in the nuclear power industry. Depending on the clamp's complexity, NuClamp requires approximately 20 lines of input data. NuClamp's input data consists of the clamp's overall dimensions, pipe size, bolt sizes and locations, applied loads, and mesh gradation.

Once the ANSYS file has been generated by NuClamp, the user can modify the ANSYS data file before the actual finite element analysis is performed.

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ACKNOWLEDGMENT

Sincere thanks are due to Thalia Anagnos of San Jose State University who made numerous helpful suggestions during her countless hours of review. Her care and attention to detail were greatly appreciated.

And finally, but most importantly, special thanks to my wife Rosalie, and daughters, Deanna and Vanessa, for their patience and understanding during the past year while I was absorbed with this thesis.

Jeffrey E. Jones

1 INTRODUCTION

1.1 Background

Pipe clamps are one type of component used to transfer load from a process pipe to a building's super structure. Examples of some typical pipe clamp configurations are shown in Figure 1. In the design of a typical nuclear power plant, clamps may be subjected to uses and loads other than what was intended by the manufacturer. In many cases, the clamp must either be replaced or modified since no convenient and economical method of analysis exists for an arbitrary pipe clamp.

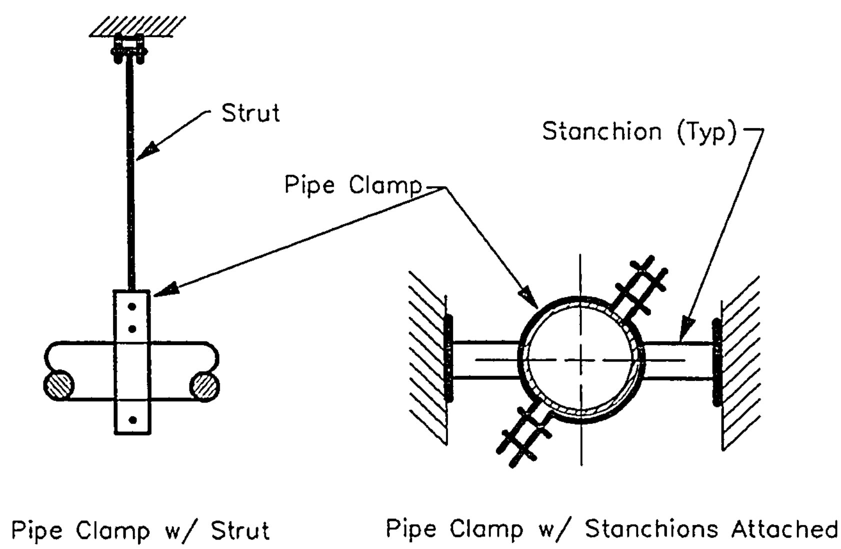

FIGURE 1 TYPICAL PIPE CLAMP CONFIGURATIONS

The analysis and modeling of any pipe clamp is very difficult because of the clamp's shape and non-linear behavior of the interface (gap) between the pipe clamp and process pipe. The usual method is to perform either a finite element analysis (FEA) or use a closed formed type of solution.

There are many computer programs written for pipe clamp analysis based on closed formed solutions. These programs are very limited since the theory used is based on specific types of pipe clamps and loading configurations. Another concern is that many overly conservative assumptions are made to simplify the theory that is used to describe the very complex behavior of the clamp.

The finite element method (FEM) is an extremely versatile, and powerful technique that is well suited to these types of problems. The down side of a FEA is that a tremendous amount of effort and time is required to generate the model, and input data. It is estimated that a typical FEA of a pipe clamp requires 40 man-hours to complete and some 500 lines of input data. This is unacceptable with today's budget and schedule constraints. Another concern is that at this time there are very few engineers who have the expertise to develop the input data for this type of analysis.

Because of these concerns with a FEA, the closed formed type of solutions are the preferred type of analysis today even though they have very limited application and can be overly conservative.

1.2 Purpose

This thesis provides the engineer with a computer program, called NuClamp, that is able to develop the complex input data for a detailed FEA in a very reasonable amount of time. This was accomplished by incorporating into NuClamp the following benefits:

- Limited User Input — For most pipe clamps, NuClamp requires only 20 to 50 lines of input.
- Limited Training — NuClamp uses a model building method that is widely used in the nuclear industry.
- Less Chance of User Errors — The required amount of input has been drastically reduced from that of a conventional FEA. For example, NuClamp requires a very general description of pipe size, clamp thickness, etc. as compared to the very detailed geometry and mesh data needed for the input of a conventional FEA.
- General Purpose — NuClamp is able to develop the input data for most standard and non-standard pipe clamps by allowing the user to build the clamp and its attachments through various input cards.

The remainder of this thesis is devoted to a detailed description of NuClamp. Chapter 2 describes the program and its limitations and assumptions. Chapter 3 discusses the behavior, considerations and modeling assumptions required to generate a finite element model of a pipe clamp. Appendices A, B, and C contain the User's, Example, and Validation manuals, respectively. The format of the manuals is typical of that used in the nuclear software industry and the manuals are written to be self-contained from the thesis.

2 PROGRAM OVERVIEW

Many of the terms that are unique to the nuclear power industry are defined for the reader in Appendix E of the user's manual.

2.1 Description

NuClamp is a pre-processor computer program that can generate the necessary finite element model and input to analyze most standard or non-standard pipe clamps.

NuClamp was developed to provide the user with a tool to perform the finite element analysis of a pipe clamp with minimal user input and training. This was accomplished by constructing an interface between the user and ANSYS (version 4.1) using a model building method that is commonly used in the nuclear power industry. Depending on the clamp's complexity, NuClamp requires approximately 20 lines of input data. NuClamp's input data consists of the clamp's overall dimensions, pipe size, bolt sizes and locations, applied loads, and mesh gradation.

Once the ANSYS file has been generated by NuClamp, the user can modify the ANSYS data file before the actual finite element analysis is performed.

2.2 NuClamp Features

The main features of NuClamp are described below:

-UNSYMMETRICAL CLAMP MODELING

Each clamp half can be modeled independently of the other. Thus the user can control the optimum mesh size for each half. This is particularly useful when each half has a different geometry, or attachment configuration.

-AUTOMATIC MESH GENERATOR

NuClamp will automatically generate the entire mesh of the clamp based on minimal user input.

-INTERACTIVE OR BATCH INPUT

The user has the choice of creating NuClamp input in either an interactive or batch mode.

-BUILT-UP ATTACHMENT OR STIFFENERS

Any rigid or flexible attachment or stiffener can be modeled.

-REFINED ATTACHMENT OR STIFFENER MESH

The user can specify the number of plate elements to be generated above the clamp surface to model an attachment as shown in Figure 8. This allows the attachment or stiffener to be modeled with a refined mesh when a more detailed stress analysis is required.

-MULTIPLE ATTACHMENTS

Up to 20 different non-standard attachments can be modeled on the clamp body.

-MIXED SUPPORT CONDITION

The user can define a boundary constraint for any node in addition to the gap element boundary constraints used to model the pipe/clamp interface. This option may be beneficial when shear lugs are used to prevent the clamp from sliding along the longitudinal axis of the pipe.

-BEAMS

Up to 50 beams can be defined to connect between any two clamp body nodes. These beams are useful when bars are welded to the clamp in order to stiffen or strengthen the clamp.

-BOLTS

Bolts can be located anywhere within the clamp's ears.

-DATA CHECK

An extensive data check of the user's input is performed prior to generating the ANSYS input.

2.3 Limitations/Assumptions

- The effects of local stress concentrations induced by the bolt holes are neglected.
- Any prying action that may develop between the clamp and the bolt head is neglected.
- Depending on the model and applied loads, the user may need to specify addition boundary conditions to provide clamp stability.
- The local axes of all beam members are predetermined and cannot be altered by the user.
- Small displacement theory is assumed.
- Only static analysis can be performed.
- All material is assumed to behavior linear-elastically.
- The clamp body is modeled with either 3-dimensional brick elements, or 2-dimensional flat quadrilateral plate elements at the center-line of the clamp.
- Quadrilateral plate elements are used to model flexible attachments or stiffeners.
- Loads applied to the clamp body will be assumed to act on the clamp's outer surface.
- In the unlikely case that any nodes of flexible attachments coincide at the same location, then the attachments are assumed to be connected.
- The axial gap spring stiffness used to model the pipe/clamp interface is equal to Young's Modulus/1000.
- Uniform surface contact is assumed between the process pipe and clamp.
- Bolts are assumed to have a spacer (sleeve) surrounding the bolts.

2.4 Capacities

Number of nodes	5000
Number of plate elements (quad + brick)	5000
Number of bolts	20
Number of attachments	20
Number of segments per attachment	20
Number of user defined beam elements	100
Number of beam elements	500
Number of external restraints	100
Number of load cases	20
Number of clamp load points	20
Number of bolt load points	20
Number of GAP elements	3000
Number control points	200

3 CLAMP BEHAVIOR AND MODELING THEORY

CLAMP BODY

The clamp body is modeled with quadrilateral (quad) plate elements at the center-line of the clamp's thickness. This is an iso-parametric membrane-bending element. For most typical clamp designs, this type of element is adequate. However, in those cases when the ratio of the clamp cross-sectional width to thickness is less than 4, a brick element should be used to represent thick plate behavior. This can be accomplished by setting #LAYER > 0 on the Plate Dimension input (see user's manual). Figure 2 shows a section of the clamp using either quad plate or brick elements.

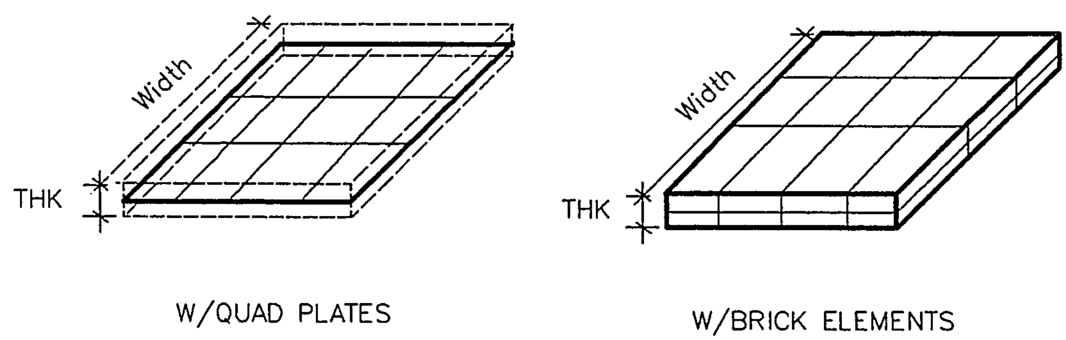

FIGURE 2 CLAMP ELEMENTS

PIPE/CLAMP INTERFACE

The interface between the process pipe and clamp is geometrically non-linear since the pipe is able only to restrain the clamp in bearing. This interface is modeled with a series of compression only spring elements called "gap elements" that are connected between the clamp nodes and an interior support (fixed boundary dof) node located at the pipe's center as shown in Figure 3. The reason for considering the pipe rather than the connection to the building as the support point in the model is for user convenience. Usually before the clamp is analyzed the entire pipe support structure is modeled with a frame analysis program. The reactions of those members that attach to the clamp are then used as loads for a detailed analysis of the clamp. This allows the user the freedom to limit the analysis to the pipe clamp and the immediate members attached to it.

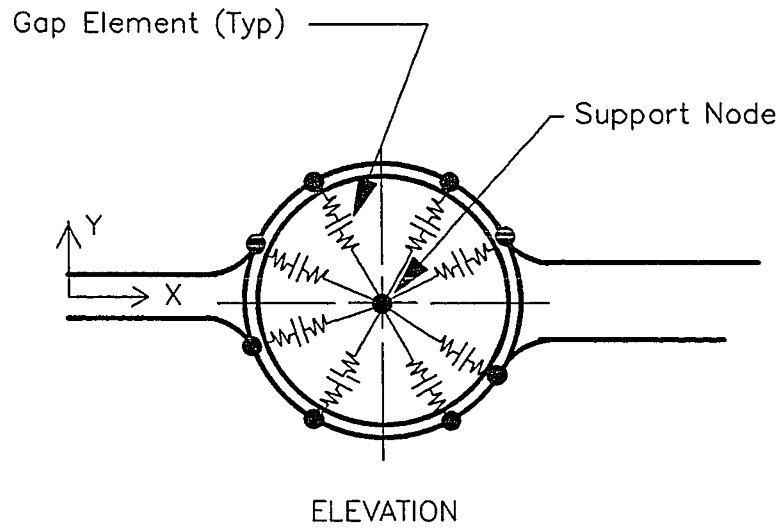

FIGURE 3 PIPE GAP ELEMENTS

The compression stiffness (K) of the gap spring element used to model the pipe/clamp interface is assumed to be equal to Young's Modulus/1000 (if Young's Modulus= 27400 and the units are in kips and inches, then the spring stiffness of each element becomes 27.4 k/in). In most situations, the spring stiffness generated using this method is sufficiently large that it accurately models the stiff pipe relative to the flexible clamp (see program assumptions).

If the user enters a coefficient of friction (Mu) greater than zero, then NuClamp will generate the necessary translational Coulomb friction elements between the clamp and pipe. NuClamp accomplishes this by specifying Mu on the ANSYS gap definition card. Both the axial and translational (in the pipe's longitudinal and circumferential directions) stiffnesses of the element are defined in Figure 4. It should also be noted that the gap element's translational stiffness definition is only used when the gap is closed and the pipe and clamp are in contact. This must be true since in order for friction to be induced, the two surfaces must be in contact. Also note that the maximum value of the friction force (Fs) that can be generated is MuN (N= normal force) at which point sliding can take place (K=0). Because of the non-linear force-displacement relationship shown in Figure 4, the problem requires an iterative or incremental solution.

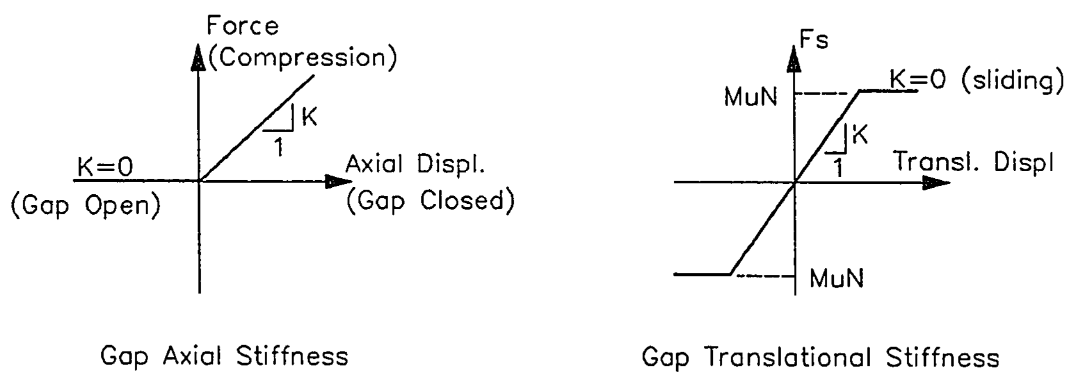

FIGURE 4 GAP ELEMENT DEFINITION

BOLTS

Pipe clamps typically can have two types of bolt/clamp connections between the two halves. The first type, shown in Figure 5, contains a spacer (sleeve) around the bolt. These spacers are used to maintain a constant distance between the top and bottom half of the clamp. With this spacer in place any actions at this connection that tend to displace the clamp inward, as shown in Figure 6A, will create compression in the sleeve. Any actions which tend to displace the joint outward (Figure 6B) will create tension in the bolt.

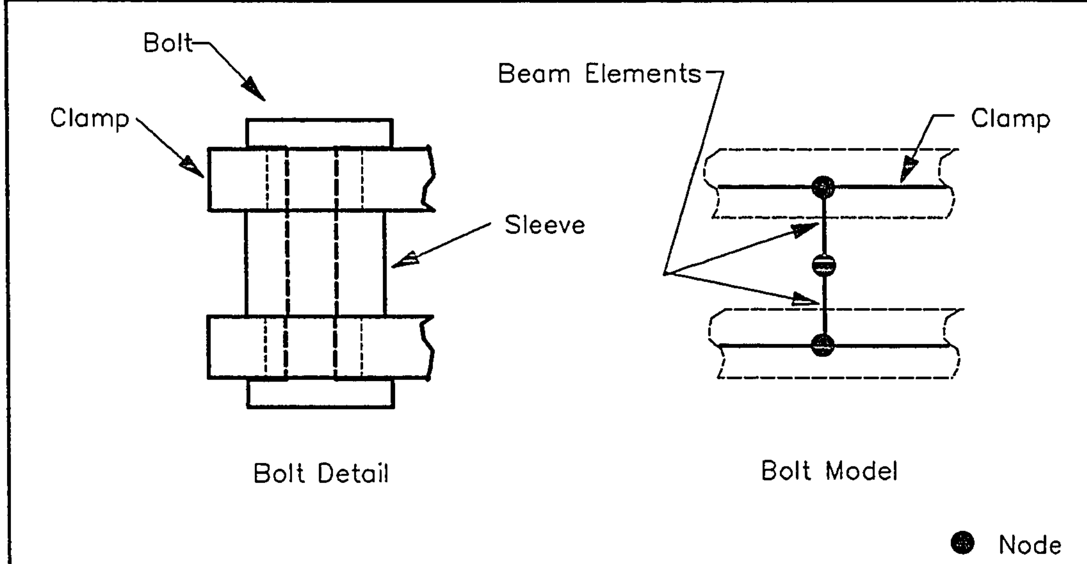

FIGURE 5 BOLT DETAIL AND MODEL

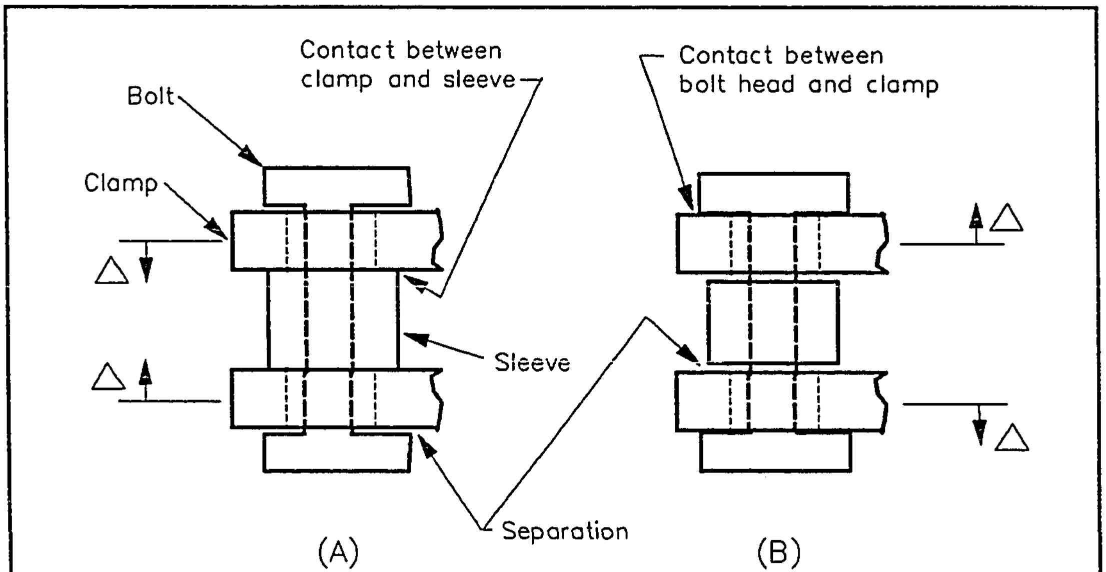

FIGURE 6 BOLT BEHAVIOR

This is a complex connection with the bolt restraining only tension and the sleeve restraining only compression actions. To simplify the analysis the joint is modeled assuming that the bolt itself is able to restrain both tension and compression. Because the cross-sectional properties of the bolt and sleeve are both significantly higher than that of the clamp this connection is similar to that of a rigid link. Therefore the overall behavior of the clamp will not be affected whether the bolt or sleeve properties are used.

Modeling of this type of behavior is accomplished with two beam elements as shown in Figure 5. The connection between the clamp body and these beams is rigid so that any rotational actions will be transferred from one side of the clamp to the other. Rotational actions are developed by the prying action between the clamp and the bolt head and sleeve.

NuClamp does not perform any bolt or sleeve stress computations. The user should realize that if the beam elements are in compression then the sleeve cross-sectional properties should be used in the stress calculation, and if the beam elements are in tension then the bolt properties should be used to calculate the stress. For any bending and shearing actions, the composite section properties of the bolt and sleeve could be used to determine the bending and shear stresses.

The second type of bolt connection is similar to the first except that there is no sleeve surrounding the bolt. This second type of connection can not be modeled directly with NuClamp. If this type of connection must be modeled, the user can insert the appropriate ANSYS cards into the ANSYS data file that NuClamp creates before submitting for the ANSYS analysis.

ATTACHMENTS AND STIFFENERS

For the modeling of attachments and stiffeners, quad plate elements and/or beam elements are used depending on the user input. The model of the attachment or stiffener should allow for a reasonably accurate transfer of the loading forces to the clamp and representation of the stiffening effect on the clamp.

A rigid attachment or stiffener is modeled as a series of rigid beams that connect between the nodes specified by the user. An example is shown in Figure 7. It should be understood that the rigid attachment is modeled by its footprint only and thus appears two-dimensional in the model. The rigid beams will force the attachment or stiffener footprint at the clamp body to maintain its original shape. A rigid attachment or stiffener should be used only in those cases when the attachment or stiffener stiffness is large relative to that of the clamp. The advantage of using the rigid attachment or stiffener option is that the speed of the finite element analysis can be increased since fewer elements are required to model the attachment or stiffener.

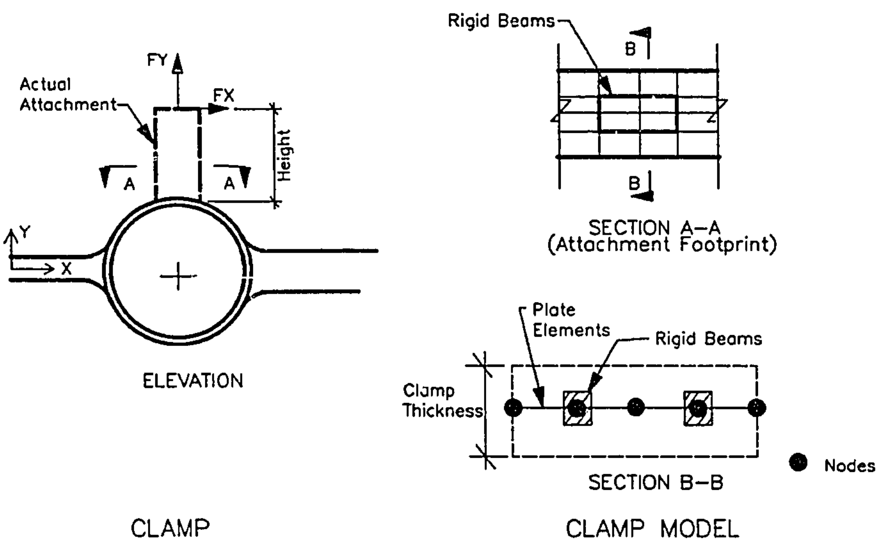

FIGURE 7 RIGID ATTACHMENT OR STIFFENER

A flexible attachment is modeled with a series of quad plates and beam elements as shown in Figure 8. The height of the attachment and dimensions of the plate elements are specified by the user. Varying these data changes the stiffness of the attachment. This allows the clamp body to deform beneath the attachment depending on the attachment's rigidity.

Since loads are applied to the top edge of the attachment, a series of rigid beam elements is generated between the top nodes to control the distribution of the stresses and strains between the top attachment nodes. Without these rigid beams, tremendous amount of local deformation would take place in the attachment at the application point of the load, that in actuality is not present. These beams allow the correct stress (or load) distribution to follow the classical MC/I or P/A stress distribution. Also refer to the Load Application Point section for more information.

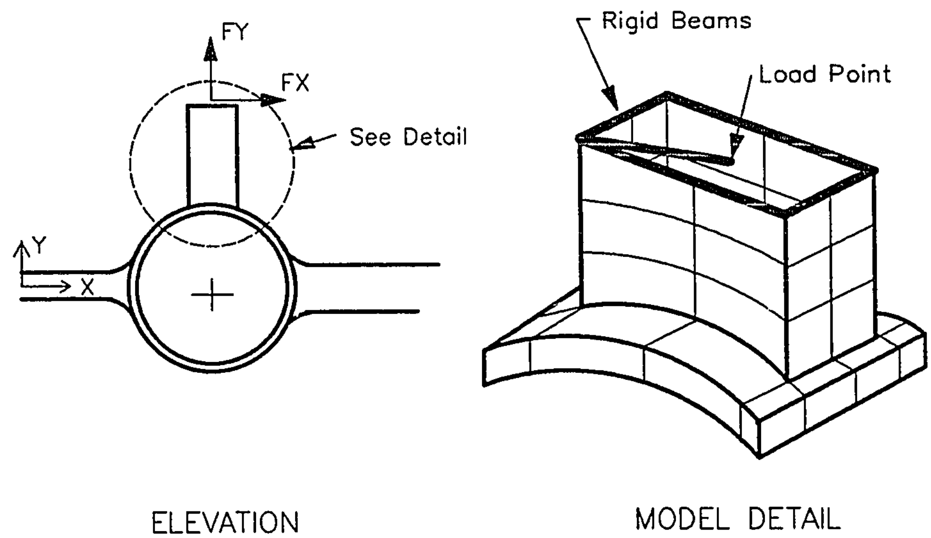

FIGURE 8 FLEXIBLE ATTACHMENT

Stiffeners are modeled the same as flexible attachments except that the rigid beams are not generated at the top edge of the stiffener, as shown in Figure 9. Rigid beams are not required since no loads are allowed to be applied through the top of the stiffener.

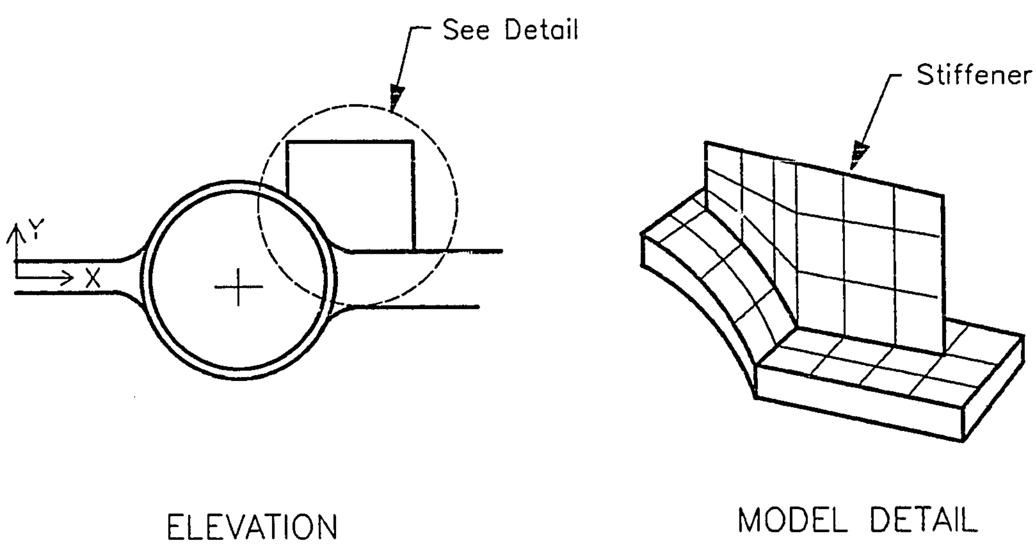

FIGURE 9 STIFFENER

LOAD APPLICATION POINT

There are two distinct types of load applications available in NuClamp. They are bolt loads and clamp body loads.

Bolt loads are loads that are applied through the bolts as shown in Figure 10. These loads are assumed to act at the bolt's mid-point node (y=0).

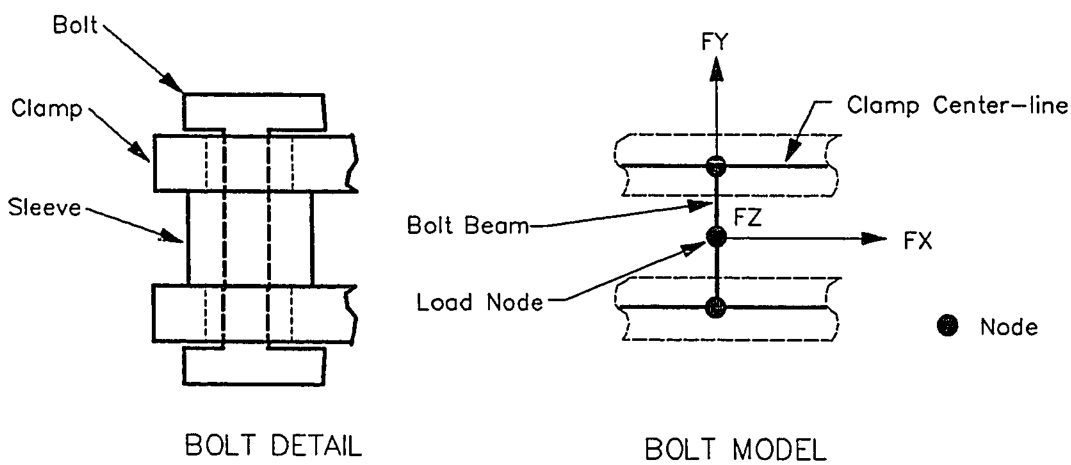

FIGURE 10 BOLT LOAD APPLICATION POINT

Clamp body loads are modeled by default (DX=DY=DZ= 0.0) as acting on the clamp's surface. The point of application of the clamp body load can be located by taking the global X, Y, and Z coordinates of the reference node and adding the user specified DX, DY, DZ dimensions to each term, respectively (see Figure 11 and 12). As discussed earlier, plate elements are two-dimensional elements connected to nodes at the center-line of the clamp. Therefore, the surface of the clamp is one-half plate thickness from the clamp center-line, as shown in Figure 11. The final Y coordinate of the load application node will also require a term (Teff as shown in Figure 13) to take into account the effect of the varying effective clamp thickness.

Loads that are applied through the reference node of a flexible load bearing attachment will be transferred from the top of the attachment to the clamp body as shown in Figure 12. This load path allows the load to be correctly transferred from the attachment to the clamp body.

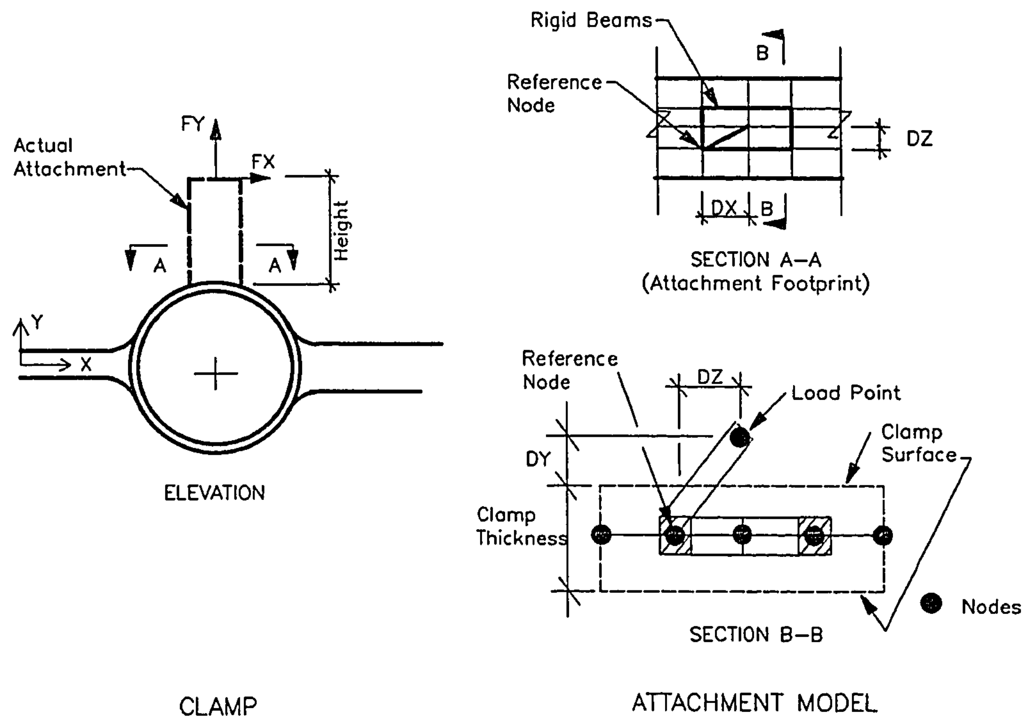

FIGURE 11 RIGID ATTACHMENT LOAD APPLICATION POINT

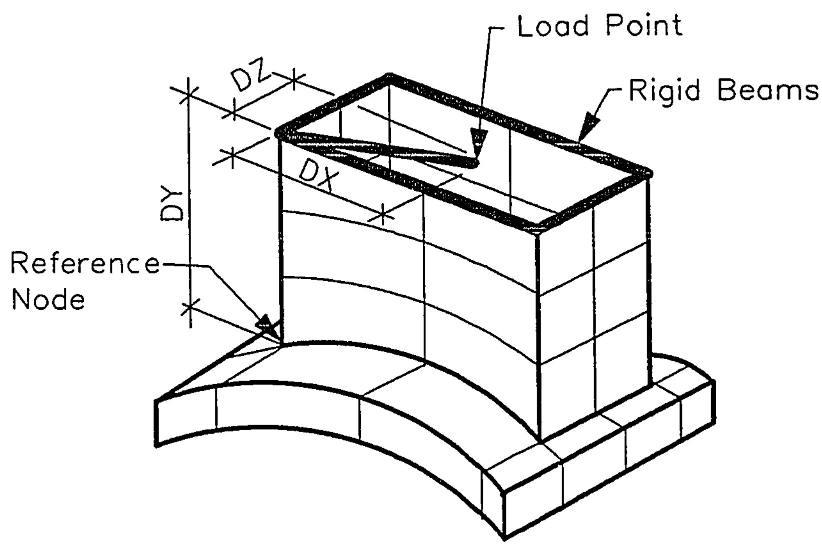

FIGURE 12 FLEXIBLE ATTACHMENT LOAD APPLICATION POINT

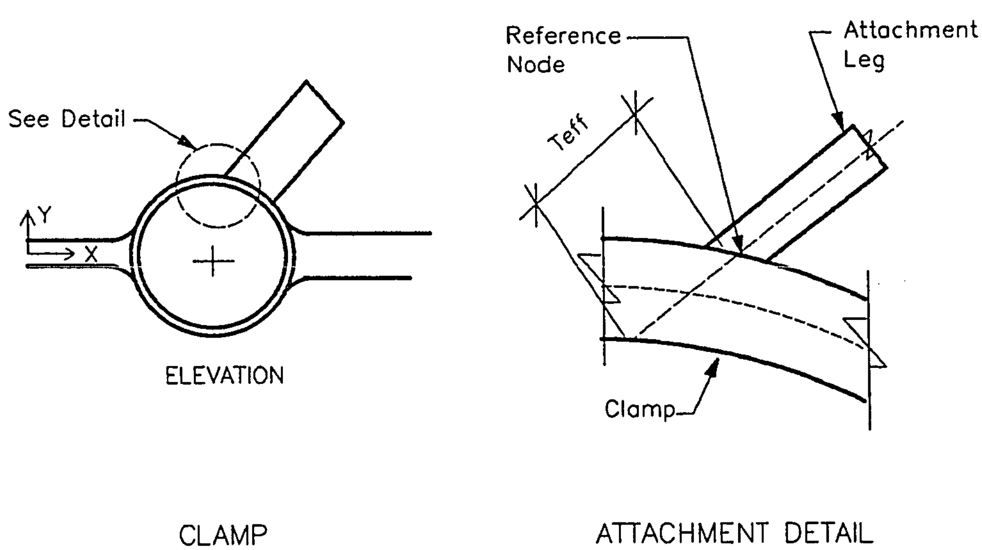

FIGURE 13 DEFINITION OF Teff

BEAM PROPERTIES

The properties of the three types of beams that are used within NuClamp are summarized in Table 1. The first type is referred to as a rigid beam. Rigid beams are used in the modeling of attachments and for transferring loads. These properties do not make the beam 100% rigid, but relative to the clamp body they provide sufficient rigidity. The second type of beam, referred to as a user defined beam, permits the user to specify a rectangular beam that connects between any two clamp body nodes. The third type of beam is for modeling bolts of diameter D.

TABLE 1[1]

ELEMENT	AREA	TORSION	BENDING Z	BENDING Y
Rigid Beam	100.0	999.0	999.0	999.0
User Beam	$W x H$	$\beta b d^3$	$\frac{H x W^3}{12}$	$\frac{W x H^3}{12}$
Bolt Beam	$\frac{\pi D^2}{4}$	$\frac{\pi D^4}{32}$	$\frac{\pi D^4}{64}$	$\frac{\pi D^4}{64}$

where:

b = maximum of W and H

d = minimum of W and H

β = a constant depending on the $\frac{b}{d}$ ratio

1 Boresi, A. P. and Sidebottom, O. M. (1985) Advanced Mechanics of Materials. John Wiley and Sons, Inc.

ELEMENT DEFINITION

The elements that have been referenced throughout this thesis are described below with the equivalent ANSYS element name.

ELEMENT	ANSYS EQUIVALENT	DESCRIPTION
Quad Plate	STIF41	This element is a two-dimensional (area) element having membrane (in-plane) stiffness but no bending (out-of-plane) stiffness. It is intended for membrane shell structures and for those structures where bending of the elements is of secondary importance. The element has three degrees of freedom at each of its four nodes: translations in the local X, Y, and Z directions of the element.
Brick	STIF45	This element is used for the three-dimensional modeling of solid structures. The element is defined by eight nodes having three degrees of freedom each: translations in the local X, Y, and Z directions of the element.
Beam	STIF4	This beam element is defined by two nodes and has tension, compression, torsion, and bending capabilities. The element has six degrees of freedom at each node: translations in the local X, Y, and Z directions and rotations about the X, Y, and Z axes of the element.

Gap	STIF52	This interface element represents two surfaces which may maintain or break physical contact and may slide relative to each other. The element is capable of supporting only compression in the direction normal to the surfaces and shear (Coulomb friction) in the tangential direction. The element has three degrees of freedoms at each node: translations in the local X, Y, and Z directions of the element.

4 CONCLUSION

NuClamp allows the engineer to perform the very accurate FEA of pipe clamps with a minimum number of man-hours. This is evident when comparing the NuClamp input (Appendix A of the validation manual) with the ANSYS input (Appendix B of the validation manual) created by NuClamp. The NuClamp input is a fraction of that required for ANSYS.

NuClamp provides the nuclear power industry with a very flexible and accurate tool for the analysis of pipe clamps as compared to the closed-formed solutions currently available.

APPENDIX A User's/Theoretical Manual

This appendix contains the User/Theoretical manual that describes in detail for the users how to use NuClamp.

The manual format is typical of that used in the nuclear industry and is written to be self-contained from the thesis.

NuClamp

User's Manual
(Includes Theoretical Discussion)

Version 1.0

DISCLAIMER OF WARRANTY

Every reasonable effort has been made to provide a comprehensive and flexible computer program. However, the computer program itself and associated documentation are supplied without representation of warranty, expressed or implied, as to their content, accuracy, or freedom from defects or errors.

RECORD OF REVISION	
REVISION	**DESCRIPTION**
0	Manual Released

LIST OF EFFECTIVE PAGES							
PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV
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ii	0	3-2	0	A-2	0	D-2	0
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				C-9	0		
				C-10	0		
				C-11	0		

PREFACE

NuClamp is a pre-processor computer program that can generate the necessary finite element model and input to analyze most standard or non-standard pipe clamps.

NuClamp was developed to provide the user with a tool to perform the finite element analysis of a pipe clamp with minimal user input and training. This was accomplished by constructing an interface between the user and ANSYS (version 4.1) using a model building method that is commonly used in the nuclear power industry. Depending on the clamp's complexity, NuClamp requires approximately 20 lines of input data. NuClamp's input data consists of the clamp's overall dimensions, pipe size, bolt sizes and locations, applied loads, and mesh gradation.

Once the ANSYS file has been generated by NuClamp, the user can modify the ANSYS data file before the actual finite element analysis is performed.

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The user can specify the number of plate elements to be generated above the clamp surface to model an attachment as shown in Figure 3-3. This allows the attachment or stiffener to be modeled with a refined mesh when a more detailed stress analysis is required.

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Up to 20 different non-standard attachments can be modeled on the clamp body.

-MIXED SUPPORT CONDITION

The user can define a boundary constraint for any node in addition to the gap element boundary constraints used to model the pipe/clamp interface. This option may be beneficial when shear lugs are used to prevent the clamp from sliding along the longitudinal axis of the pipe.

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An extensive data check of the user's input is performed prior to generating the ANSYS input.

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- The axial gap spring stiffness used to model the pipe/clamp interface is equal to Young's Modulus/1000.
- Uniform surface contact is assumed between the process pipe and clamp.
- Bolts are assumed to have a spacer (sleeve) surrounding the bolts.

1.4 Input Format

The input format of NuClamp allows the user the option of either creating the input interactively or creating a data file for batch analysis. NuClamp performs extensive error checking of the data prior to generating the ANSYS input in either mode.

INTERACTIVE

The interactive free format input option of NuClamp prompts the user for the required input parameters. Any valid system delimiter (space (s) or comma) can be used to separate the input parameters. This interactive option completely eliminates the need to learn many system dependent editing commands that may otherwise be required to create an input data file.

The interactive session creates a data file that contains the user input. This ASCII data file can subsequently be edited by the user using any ASCII editor and then resubmitted through NuClamp for batch analysis as explained below.

The input file that is created contains headers directly above each line of input (see example problem in Appendix A). These headers are placed in the file for user readability and are required by NuClamp. Text is not required on a header line; therefore, a header line may be any line, blank or with any text.

BATCH

An input batch file for NuClamp can be created either from scratch (not recommended) or by using the data file created in the interactive session. This batch file contains the necessary user input required by NuClamp. This file can be edited using any ASCII system editor and re-submitted through NuClamp. The batch mode is very useful when making minor changes to the model rather than repeating the entire interactive input process.

The order of the input data in the input file must follow exactly with the order as presented in this manual. For example: The title must be before the material properties, then followed by the clamp dimensions, etc. The first two lines of the batch file summarize for NuClamp the various data that are to follow in the file. NuClamp uses this summary in reading the input data file. The following is a description of each of the parameters:

PARAMETER	DESCRIPTION
#BOLT	Total number of bolts (Section 3.5)
#CTRL	Total number of control points (Section 3.6)
#LC	Total number of load cases (Section 3.10)
#C-PT	Total number of clamp load points (Section 3.10)
#B-PT	Total number of bolt load points (Section 3.10)

#BEAMS	Total number of user defined beams (Section 3.8)
#ATT	Total number of attachments/stiffeners (Section 3.7)
#REST	Total number of user defined external restraints (Section 3.9)

For any option that is not being used, the batch file will contain no headers relating to that option. For example: Should #REST= 0, indicating that there are no user defined restraints, then the two header lines that would normally precede the restraint data will not be written to the batch file.

As with the interactive session, the format of the data on the lines in the batch file is free format except that the only valid delimiter is the space (commas cannot be used).

2 HOW TO START NuClamp

To begin NuClamp on a CYBER NOS2 computer, enter the following commands:

GET,NUCLAMP/UN=*userid*
BEGIN,,NUCLAMP

where:

userid=	User ID on the system where the NuClamp executable resides. The user ID can be obtained from the system manager.

3 INPUT DATA DESCRIPTION

All input data units must be in consistent units (based on Young's Modulus). For example: If Young's Modulus is entered in kips and inches, then the units for the problem are kips and inches. If Young's Modulus is entered in tons and centimeters, then the units for the problem are tons and centimeters.

Some of the input data requires the use of an I-J mapping technique. This method uniquely labels each vertical grid line as an I-line and each horizontal grid as a J-line. This allows specific points, such as bolt locations, to be referenced by a unique I-J combination. See Appendix B for complete details.

The term *card* is used throughout this manual to describe a line of input parameters. For Example: I-START and J-START are two parameters on the Bolt Connectivity card. In those cases where more than one card of the same type is required, be sure that each card is entered on a separate line.

3.1 TITLE (required)

TITLE

TITLE : Problem title (30 characters maximum)

3.2 MATERIAL PROPERTIES (required)

The material properties for both the clamp and bolts are assumed to be the same.

YOUNG'S MODULUS	POISSON'S RATIO

YOUNG'S MODULUS : Young's Modulus of Elasticity for the clamp and bolt material

POISSON'S RATIO : Poisson's Ratio for the clamp and bolt material

3.3 DIMENSIONS (required)

The clamp as shown in Figure 3-1 is divided into a top and bottom half. The top half is that half of the clamp assembly that lays above the XZ plane and the bottom half lays below the XZ plane. Each half is modeled with its own set of attributes; therefore, the Dimension data below is required for each half even though both the halves may be identical. The variables for the top half (XMAX1, THICK1, etc.) must be entered first, followed by the data for the bottom half (XMAX2, THICK2, etc.) on the succeeding line. The orientation and location of the global coordinate axes is fixed along the clamp's left edge and center-line. For further explanation refer to Figure 3-1 and Appendix B.

XMAX	ZMAX	THICK	SPACE	#LAYER	#I	#J	IB1	IB2	IB3	IB4	RAD

XMAX	:	Clamp overall X dimension for the clamp half
ZMAX	:	Clamp overall Z dimension for the clamp half (width)
THICK	:	Clamp thickness for the clamp half
SPACE	:	Clamp clear dimension between the clamp's top and bottom halves. SPACE1 and SPACE2 refer here to the left and right side of the clamp, respectively, as shown in Figure 3-1.
#LAYER	:	=0 Quad plate elements are generated for the clamp body >0 Brick elements will be generated across the clamp's body thickness. The value of #LAYER specifies the number of brick elements that will be stacked along the clamp thickness. For example: if #LAYER equals 2, then the clamp thickness will be modeled with 2 layers of brick elements (the thickness of each layer will be the clamp thickness divided by #LAYERS).
#I	:	Total number of I-lines for the clamp half
#J	:	Total number of J-lines for the clamp half
IB1, IB2	:	I-line number at the start and end of the left side clamp bend for the clamp half
IB3, IB4	:	I-line number at the start end of the right side clamp bend for the clamp half

RAD : Bend radius for the clamp half. Both the left and right side bend are assumed to be the same.

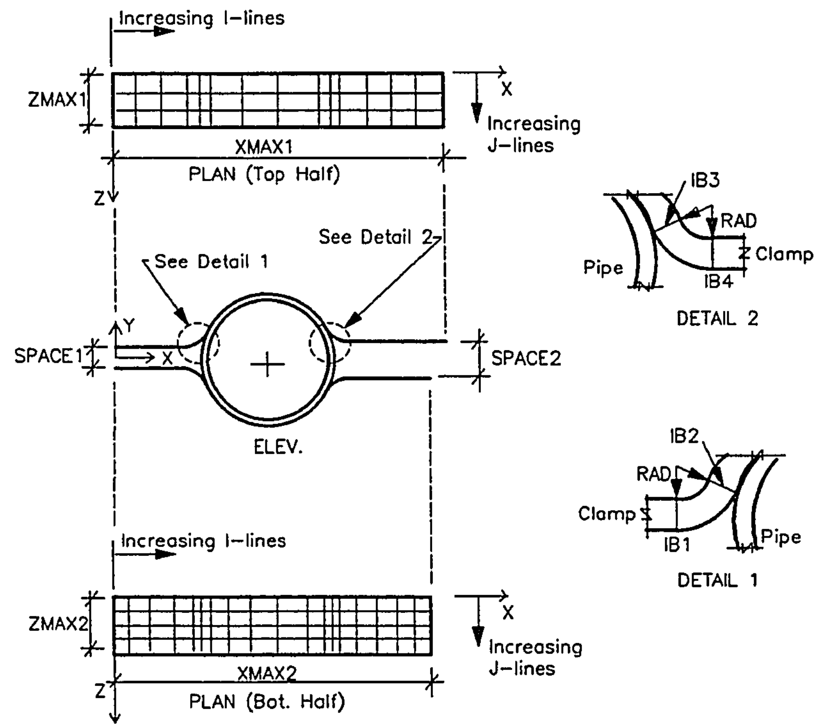


FIGURE 3-1 CLAMP DIMENSIONS

3.4 PIPE DATA (required)

OD	MU	X-CENTER

OD : Process pipe's outside diameter

MU : Coefficient of friction between the process pipe and clamp body.
=0 neglect friction
>0 friction considered and the coefficient of friction is MU

X-CENTER : Global X coordinate to the center of the process pipe

3.5 BOLTS

NO. OF BOLTS

NO. OF BOLTS : Total number of bolts that span between the two clamp halves

BOLT CONNECTIVITY

The following Bolt Connectivity data required for each bolt.

I-START	J-START	I-END	J-END	X	Z	DIA

I-START : Corresponding I-line number at the bolt's start node

J-START : Corresponding J-line number at the bolt's start node

I-END : Corresponding I-line number at the bolt's end node

J-END : Corresponding J-line number at the bolt's end node

X : Global X coordinate to the bolt's center-line

Z : Global Z coordinate to the bolt's center-line

DIA : Effective bolt diameter to be used in generating the beam element stiffness.

3.6 CONTROL POINTS

A control point allows the user to define the coordinates of a particular node, whereby overriding the default coordinates that NuClamp would have otherwise calculated. This option allows the user to control the mesh to suit the particular clamp. A complete description of control points can be found in Appendix B.

NO. OF CONTROL POINTS

NO. OF CONTROL POINTS : Total number of control points to be entered on the following Control Point Definition cards.

CONTROL POINT DEFINITION

Any control point that is not within the clamp ears must be defined in the cylindrical coordinate system as shown in Figure 3-2. In this case ANG would be entered as the X coordinate and Z remains in the rectangular coordinate system.

Any node that is located along a clamp edge or boundary cannot be redefined. However, control points that move the node along a boundary edge are acceptable. Boundary edges are any free edge or the start and end of a bend radius (IB1, IB2, IB3, IB4).

Figure 3-2 displays for example, five control points with their corresponding X (or THETA) and Z coordinates (1 through 5). For clarity the corresponding I and J-line numbers are not shown. These would be represented by (I1,J1), (I2,J2), etc.

The following Control Point data is required for each control point. Refer to Figure 3-2 for additional information.

I	J	X	Z

I : Corresponding I-line number of the control point

J : Corresponding J-line number of the control point

X : Global X coordinate of the control point or angular coordinate if the control point in not in the clamp ears. The angular coordinate is measured counter-clockwise from the XZ plane.

Z : Global Z coordinate of the control point

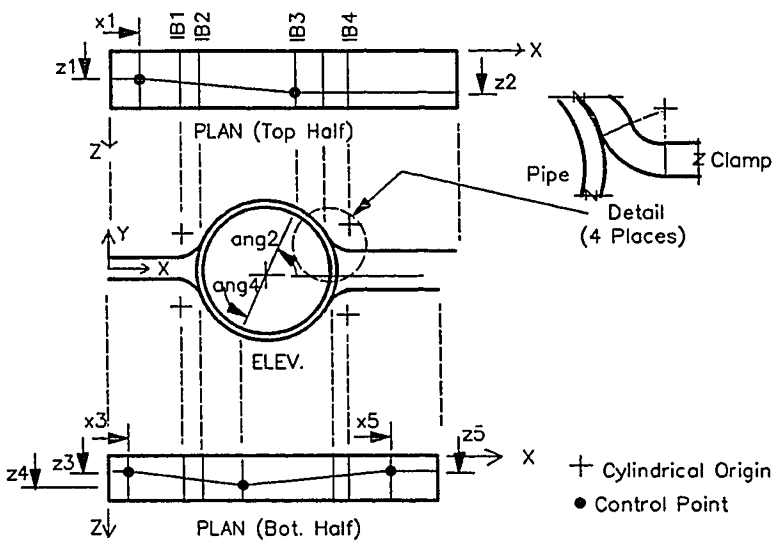


FIGURE 3-2 CONTROL POINT DEFINITION

3.7 BUILT-UP ATTACHMENTS

NO. OF ATTACHMENTS

NO. OF ATTACHMENTS : Total number of attachments

ATTACHMENT DEFINITION[1]

The following Attachment Definition data is required for each attachment. Following each Attachment Definition card will be the corresponding Segment Definition cards that locate the attachment and define its footprint. Each subsequent attachment will follow this format of one Attachment Definition card, then the segment cards. Refer to Figure 3-3 for additional information.

If either THICKNESS, HEIGHT, or DIV is zero, then a rigid attachment footprint will be generated.

#SEG	THICKNESS	HEIGHT	ANGLE	TYPE	DIV

#SEG : Total number of segments cards required to model the attachment

THICKNESS : Thickness of attachment

HEIGHT : Absolute height at reference node of attachment measured from the clamp's outer surface (HEIGHT$\geq$ 0.)

ANGLE : Attachment orientation angle in the XY plane from the XZ plane (see Figure 3-3). Clockwise is positive rotation about positive Z.

TYPE : 0= Load bearing attachment
1= Non-load bearing attachment (stiffener)

DIV : Number of Quad elements generated along attachment height

1 The top edge of any flexible attachment will always be plane and perpendicular to the reference node leg as shown in Figure 3-3.

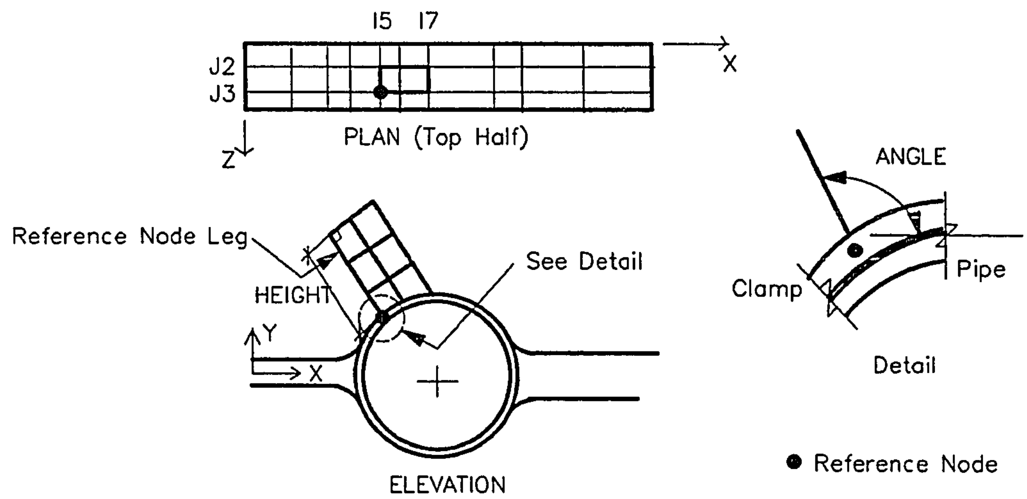


FIGURE 3-3 BUILT-UP ATTACHMENTS

SEGMENT DEFINITION

Segment Definition is used to generate the footprint of the attachment or stiffener. The method of generating the footprint is similar to that of a child's connect the dots coloring book, except here we specify the dots (or nodes) with a (I,J) combination for both the beginning (start) and end of the line (segment). An attachment may be made up of multiple segments. The first (I-START,J-START) of the attachment is known as the reference node which is used to define the loads in section 3.10. With the exception of the reference node, no particular order of the Segment Definition cards is required. The following Segment Definition data is required for each segment of the attachment.

I-START	J-START	I-END	J-END

I-START	:	Corresponding I-line at the element's start node[2]
J-START	:	Corresponding J-line at the element's start node
I-END	:	Corresponding I-line at the element's end node
J-END	:	Corresponding J-line at the element's end node

2 Attachment segments can also be specified to run diagonally across a plate element in addition to running along a line of constant I or J. This may be required in those cases where the attachment is rotated 45 degrees to the mesh in the XZ plane. For example: If I-START= 5, J-START= 3 and I-END= 6, J-END= 2, then one element will be generated that connect the nodes (5,3) with (6,2).

For example, four Segment Definition cards are required for the rectangular footprint shown in Figure 3-3. With the reference node located as shown in the figure, the data on the Segment Definition cards might be as follows:

I-START	J-START	I-END	J-END
5	3	7	3
7	3	7	2
7	2	5	2
5	2	5	3

3.8 BEAM DATA

NO. OF BEAMS

NO. OF BEAMS : Number of user defined beam elements

BEAM CONNECTIVITY

The following Beam Connectivity data is required for each beam. Refer to Figure 3-4 for additional information.

I-START	J-START	I-END	J-END	W	H

I-START, J-START : Corresponding I and J-line number at the beam's start node

I-END, J-END : Corresponding I and J-line number at the beam's end node

W : Width of member parallel to the global XZ plane

H : Height of member normal to member's longitudinal axis

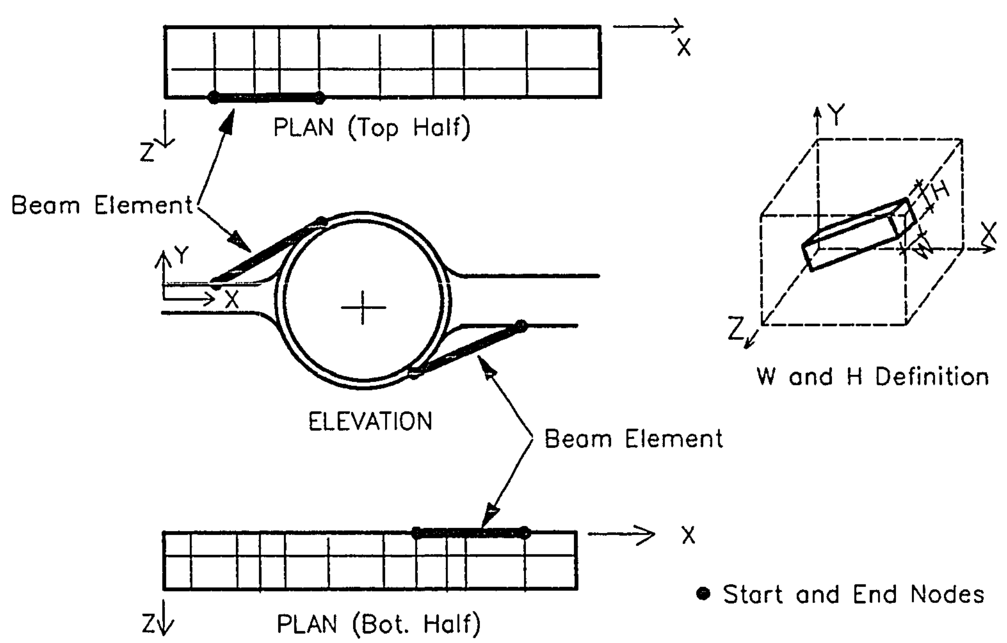


FIGURE 3-4 BEAM DEFINITION

3.9 RESTRAINTS

NuClamp automatically generates the required restraints to model the clamp/pipe interface. However, in some cases the user may be required to impose additional external restraints to provide model stability. Another case where the restraint option may be needed is if shear lugs are welded to the pipe to prevent the clamp from sliding along the pipe.

NO. OF RESTRAINTS

NO. OF RESTRAINTS : Total number of external restraints (boundary conditions)

RESTRAINT DEFINITION

The following Restraint Definition data is required for each restraint node. All restraint definitions are in the global rectangular coordinate system.

I	J	TX	TY	TZ	RX	RY	RZ

I	:	Corresponding I-line number of the restraint node
J	:	Corresponding J-line number of the restraint node
TX, TY, TZ	:	Translational restraint condition for the nodes in the global X, Y, or Z axes. 0= unrestrained 1= restrained
RX, RY, RZ	:	Rotational restraint condition for the node about the global X, Y, or Z axes. 0= unrestrained 1= restrained

3.10 LOADS (required)

Two types of load applications are available: (1) Plate loads, and (2) Bolt loads. Plate loads are loads which are applied to the clamp body through an attachment reference node, and bolt loads are loads which are applied to the bolt's mid-point (y= 0.0). The user must first enter all the required data for the plate load definition (if applicable), followed by the data for the bolt load definition (if applicable).

NO. OF LOAD CASES

NO. OF LOAD CASES : Total number of load cases

PLATE LOAD DEFINITION

NO. OF PLATE LOAD POINTS

NO. OF PLATE LOAD POINTS : Total number of points where the loads are to be applied to the clamp body (excluding any loads applied to the bolts).

LOAD POINT LOCATION

The following Load Point Location data is required for each Plate Load Point. Figure 3-5 shows the relationship between the load point and the reference node. Although this figure shows an example only for the top half of the clamp, a plate load may be applied to either half. Additional detail on the reference node is shown in Figure C-12.

I	J	DX	DY	DZ

I : Corresponding I-line number of the load application point (Reference Node, see section 3.7)

J : Corresponding J-line number of the load application point (Reference Node, see section 3.7)

DX : Dimension in the global X direction to the load point relative to the reference point defined by (I,J)[3]

DY : Dimension in the global Y direction to the load point relative to the reference point defined by (I,J)

3 NuClamp will automatically include the distance from the I,J node specified to the clamp's outer surface, therefore do not include the clamp thickness dimension when calculating DX, DY, or DZ. The sign of DX, DY, and DZ is the same as the global rectangular coordinate system.

DZ : Dimension in the global Z direction to the load point relative to the reference point defined by (I,J)

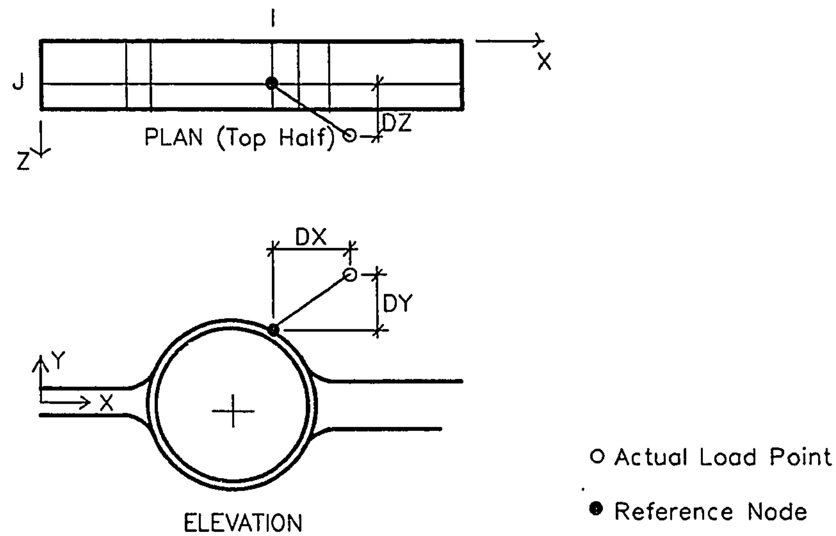


FIGURE 3-5 LOAD OFFSET

PLATE LOAD

The Plate Load data is required for each Plate Load Point and Load Case.

FX	FY	FZ	MX	MY	MZ

FX : Applied force in the global X direction

FY : Applied force in the global Y direction

FZ : Applied force in the global Z direction

MX : Applied moment about the global X axis

MY : Applied moment about the global Y axis

MZ : Applied moment about the global Z axis

BOLT LOAD DEFINITION

NO. OF BOLT LOAD POINTS

NO. OF BOLT LOAD POINTS	:	Total number of bolts which are to be loaded

BOLT LOAD POINT LOCATION

The following Bolt Load Point Location data is required for each Bolt Load Point.

BOLT#

BOLT#	:	The bolt number. Each bolt is assigned a bolt number consecutively as they are entered on the bolt cards in section 3.5. For example: If the second bolt entered on the bolt card has an applied load then the BOLT# would be 2.

BOLT LOAD

The following Bolt Load data is required for each Bolt Load Point and Load Case.

FX	FY	FZ

FX	:	Applied force in the global X direction
FY	:	Applied force in the global Y direction
FZ	:	Applied force in the global Z direction

A EXAMPLE PROBLEM

The example problem shown in Figure A-1 is a typical two bolt clamp with a 9 kip load applied to the left bolt. The process pipe has an outside diameter of 12 inches and is located at 10-5/8 inches from the left edge of the clamp as shown in Figure 1. The stock size of both clamp halves is 3 wide inches by 1/2 inch thick with an overall length of 21.5 inches. Two 1-1/2 inch diameter bolts are used to connect the two clamp halves.

Since the clamp and loads are symmetrical about the XZ plane, a symmetrical mesh will be used. A total of 76 quad plate elements will be generated to model each clamp body half. Quad plate elements are selected because of the 6 to 1 width to thickness ratio of the clamp cross-section. Because of the manner in which the clamp is loaded through the bolt, it is unlikely that any appreciable out of plane bending (or warpage) across the clamps' width will take place, therefore the quad plate elements are acceptable.

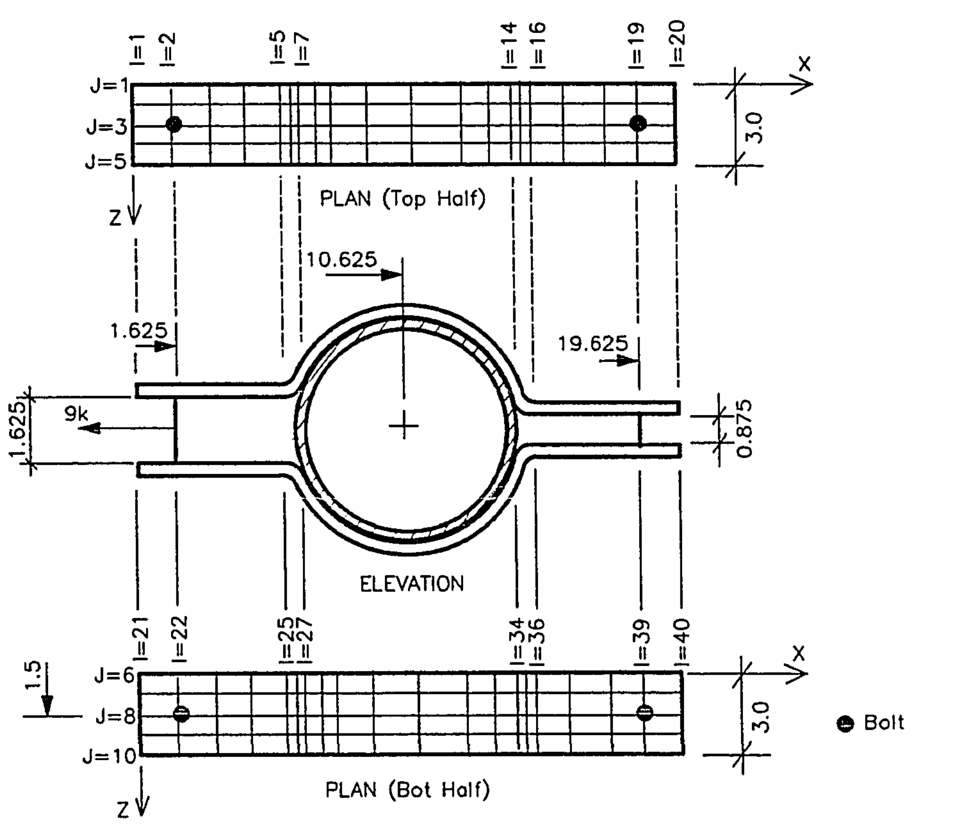
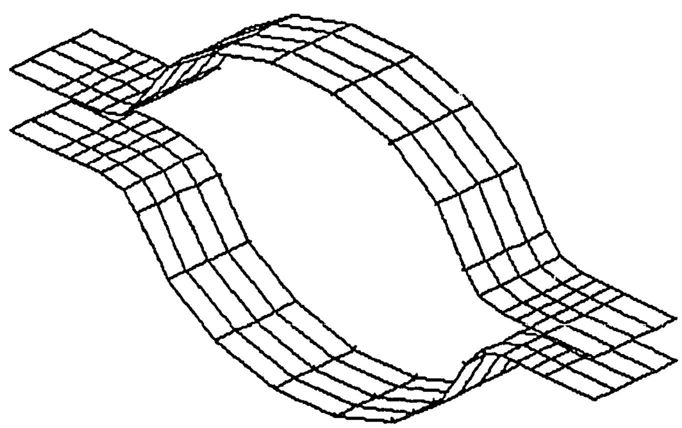


FIGURE A-1 EXAMPLE PROBLEM MODEL

The NuClamp input required is as follows:

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   2     0     1    0     1     0     0     0
TITLE:
TEST1
MATERIAL PROPERTIES:--------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
         29000.           .200
DIMENSIONS:-----------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J  I1  I2  I3  I4    RAD
 21.500  3.000   .500  1.625      0 20  5   5   7  14  16  1.000
 21.500  3.000   .500   .875      0 20  5  25  27  34  36  1.000
PIPE DATA:------------------------------------------------------------
    OD     MU X-CENTER
12.000  .000   10.625
BOLT DATA:------------------------------------------------------------
I-START J-START   I-END   J-END       X       Z      DIA
      2       3      22       8  1.625   1.500    1.500
     19       3      39       8 19.625   1.500    1.500
BOLT LOAD DATA:-------------------------------------------------------
LOAD BOLT#
  1
LC#      FX       FY       FZ
  1      -9.      0.       0.
```



, TEST1

FIGURE A-2   EXAMPLE PROBLEM PLOT[4]

4 This plot was generated by using the plotting module of ANSYS.

B MESH GENERATOR[5]

NODE POINT DEFINITION AND GENERATION

The technique selected for nodal point definition and automatic generation has been selected so that the user has control over the size and configuration of the finite element model while providing a minimum of input. The basic concept of the technique is that a point on the surface can be located by any two independent axes which need not be orthogonal. The system used in NuClamp is called an I-J mapping technique where I represents lines of constant value which must run roughly parallel to the global Z axis and J represents lines of constant value which run roughly parallel to the global X axis. The cardinal rule, as with contour lines, is that a line of constant value can not cross similar lines of higher or lower values.

An analogy using a street map will help illustrate the system. Assume streets called avenues run in a north-south direction, and streets called boulevards run in an east-west direction. The distance between adjacent avenues and boulevards is not important when one wants to locate a particular intersection. All that is necessary is that the name of the avenue and boulevard are known, and the location of the intersection is thus determined. At this point let us impose the restriction that no avenue can cross any other avenue, and no boulevard can cross any other boulevard. Each intersection is therefore uniquely located by a specific avenue and a specific boulevard.

For our mapping technique let us call the avenues I-lines, and the boulevards J-lines. The I-lines are numbered consecutively from one to a maximum #I, which is determined by the user. The J-lines are also numbered consecutively from one to a maximum #J. The first J-line locates the edge of the clamp along the X axis, the last J-line locates the edge of the clamp parallel to the X axis at Z= ZMAX. The first I-line locates the left side of the clamp and the last I-line locates the right side of the clamp. It is important to note that any opposite two edges must remain parallel. All other interior points having a required location such as bolts and attachments now have to be specified by an I-line and J-line address.

Going back to the street map, any intersection of interest can also be uniquely located by knowing its latitude and longitude, which is a measure of distance of the point from a given reference. Similarly, bolts and attachments are uniquely located by their global X and global Z dimensions from a fixed reference point. With the I-J mapping technique, once the I and J values of known locations, along with their X and Z coordinate dimension are specified, all other I and J lines can be obtained by linear interpolation logic which is contained within the NuClamp program.

5 CDC BASEPLATE II User Manual, Publication No. 84002770 rev. D

MESH GENERATION PROCEDURE

1. Straight segments are generated between control points defined by the same I or J line.

2. Any I or J-line extending from the edge of the plate to the first control point has the same (X or Z) coordinates as the control point. For rectangular plates this means that the line segment will be automatically generated from the control point perpendicular to the edge of the plate.

3. I or J lines which are necessary to define a fine mesh but contain no control points are automatically generated by linear interpolation.

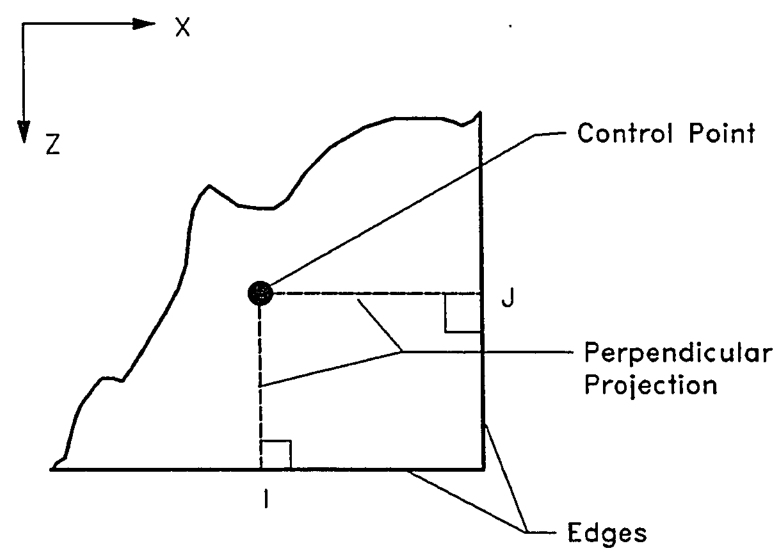


FIGURE B-1 MESH PROJECTION EXAMPLE

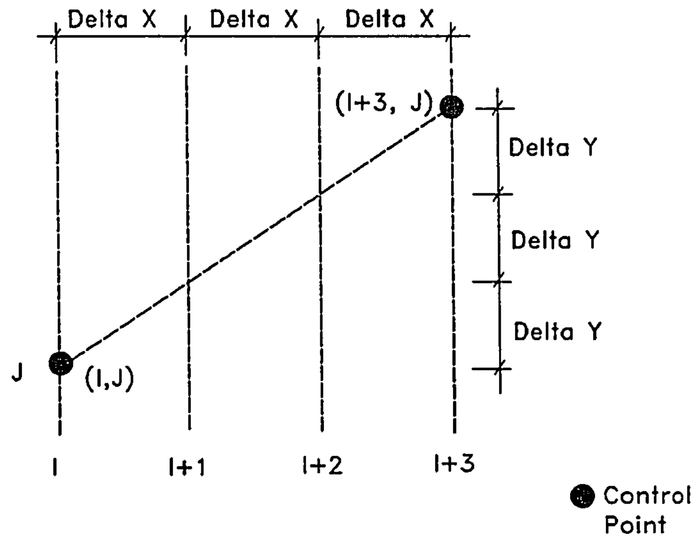


FIGURE B-2 LINEAR INTERPOLATION EXAMPLE

The coordinate of nodes (I+1,J) and (I+2,J) are equally spaced between the coordinates of the control points at (I,J) and (I+3,J) as shown in Figure B-2.

The finite element mesh generated by NuClamp consists entirely of flat quadrilateral or brick elements. In sketching the mesh the user must insure that two lines of constant I or J do not intersect. In other words, each node of the quadrilateral and brick element must have a unique (I,J) location as shown in Figure B-3.

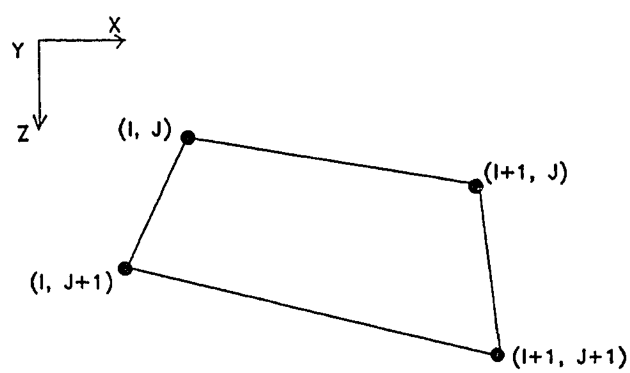


FIGURE B-3 QUAD/BRICK ELEMENT USING I, J MAPPING SYSTEM

C THEORY (Modeling)

CLAMP BODY

The clamp body is modeled with quadrilateral (quad) plate elements at the center-line of the clamp's thickness. This is an iso-parametric membrane-bending element. For most typical clamp designs, this type of element is adequate. However, in those cases when the ratio of the clamp cross-sectional width to thickness is less than 4, a brick element should be used to represent thick plate behavior. This can be accomplished by setting #LAYER > 0 on the Plate Dimension input (see user's manual). Figure C-1 shows a section of the clamp using either quad plate or brick elements.

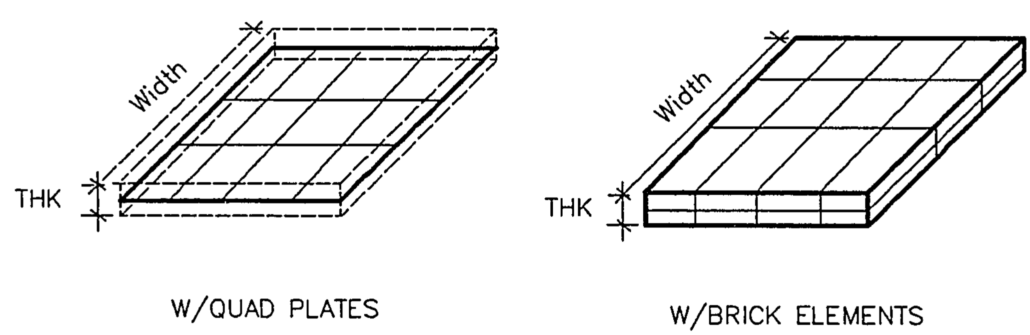


FIGURE C-1 CLAMP ELEMENTS

PIPE/CLAMP INTERFACE

The interface between the process pipe and clamp is geometrically non-linear since the pipe is able only to restrain the clamp in bearing. This interface is modeled with a series of compression only spring elements called "gap elements" that are connected between the clamp nodes and an interior support (fixed boundary dof) node located at the pipe's center as shown in Figure C-2. The reason for considering the pipe rather than the connection to the building as the support point in the model is for user convenience. Usually before the clamp is analyzed the entire pipe support structure is modeled with a frame analysis program. The reactions of those members that attach to the clamp are then used as loads for a detailed analysis of the clamp. This allows the user the freedom to limit the analysis to the pipe clamp and the immediate members attached to it.

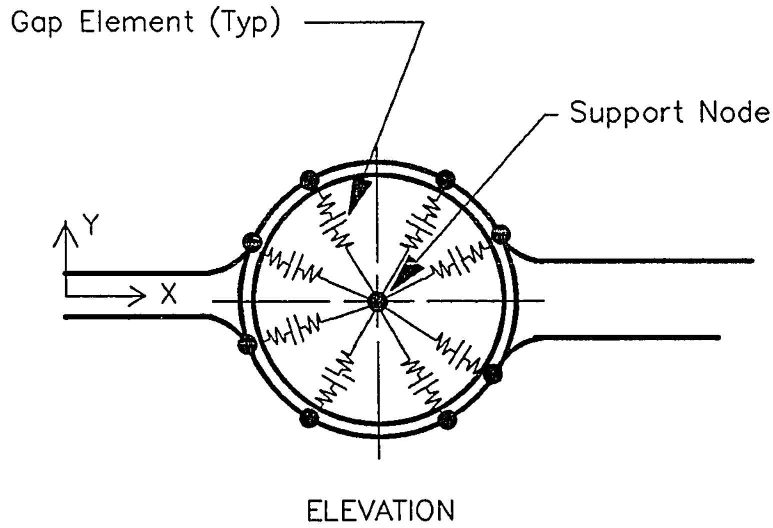


FIGURE C-2 PIPE GAP ELEMENTS

The compression stiffness (K) of the gap spring element used to model the pipe/clamp interface is assumed to be equal to Young's Modulus/1000 (if Young's Modulus= 27400 and the units are in kips and inches, then the spring stiffness of each element becomes 27.4 k/in). In most situations, the spring stiffness generated using this method is sufficiently large that it accurately models the stiff pipe relative to the flexible clamp (see program assumptions).

If the user enters a coefficient of friction (Mu) greater than zero, then NuClamp will generate the necessary translational Coulomb friction elements between the clamp and pipe. NuClamp accomplishes this by specifying Mu on the ANSYS gap definition card. Both the axial and translational (in the pipe's longitudinal and circumferential directions) stiffnesses of the element are defined in Figure C-3. It should also be noted that the gap element's translational stiffness definition is only used when the gap is closed and the pipe and clamp are in contact. This must be true since in order for friction to be induced, the two surfaces must be in contact. Also note that the maximum value of the friction force (Fs) that can be generated is MuN (N= normal force) at which point sliding can take place (K=0). Because of the non-linear force-displacement relationship shown in Figure C-3, the problem requires an iterative or incremental solution.

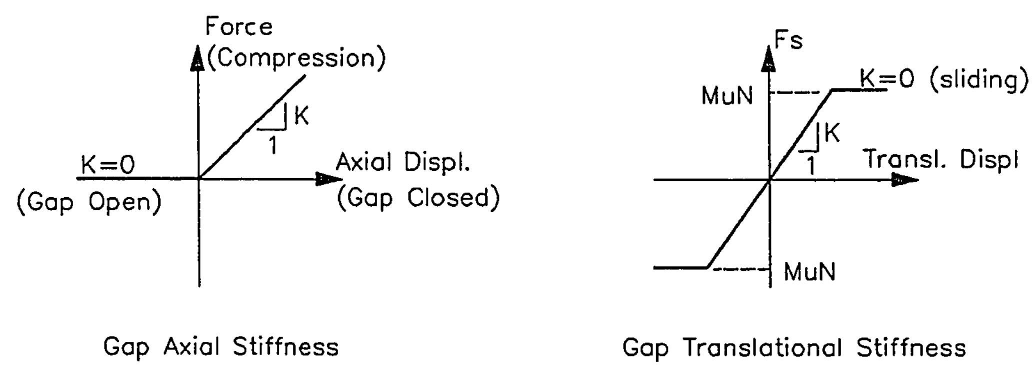


FIGURE C-3 GAP ELEMENT DEFINITION

BOLTS

Pipe clamps typically can have two types of bolt/clamp connections between the two halves. The first type, shown in Figure C-4, contains a spacer (sleeve) around the bolt. These spacers are used to maintain a constant distance between the top and bottom half of the clamp. With this spacer in place any actions at this connection that tend to displace the clamp inward, as shown in Figure C-5A, will create compression in the sleeve. Any actions that tend to displace the clamp outward (Figure C-5B) will create tension in the bolt.

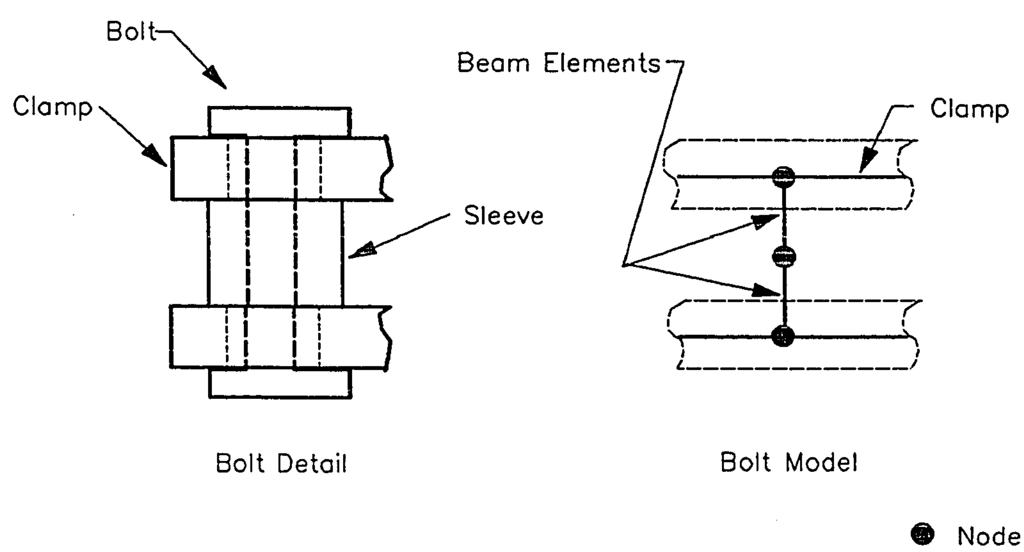


FIGURE C-4 BOLT DETAIL AND MODEL

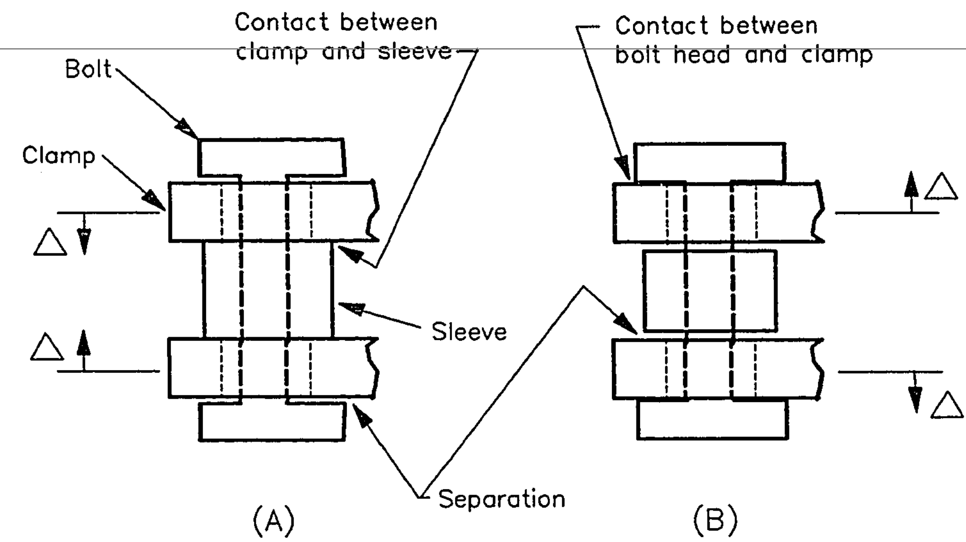


FIGURE C-5 BOLT BEHAVIOR

Modeling of this type of behavior is accomplished with two beam elements as shown in Figure C-4. The connection between the clamp body and these beams is rigid so that any rotational actions will be transferred from one side of the clamp to the other. Rotational actions are developed by the prying action between the clamp and the bolt head and sleeve.

NuClamp does not perform any bolt or sleeve stress computations. The user should realize that if the beam elements are in compression then the sleeve cross-sectional properties should be used in the stress calculation, and if the beam elements are in tension then the bolt properties should be used to calculate the stress. For any bending and shearing actions, the composite section properties of the bolt and sleeve could be used to determine the bending and shear stresses.

The second type of bolt connection is similar to the first except that there is no sleeve surrounding the bolt. This second type of connection can not be modeled directly with NuClamp. If this type of connection must be modeled, the user can insert the appropriate ANSYS cards into the ANSYS data file that NuClamp creates before submitting for the ANSYS analysis.

ATTACHMENTS AND STIFFENERS

For the modeling of attachments and stiffeners, quad plate elements and/or beam elements are used depending on the user input. The model of the attachment or stiffener should allow for a reasonably accurate transfer of the loading forces to the clamp and representation of the stiffening effect on the clamp.

A rigid attachment or stiffener is modeled as a series of rigid beams that connect between the nodes specified by the user. An example is shown in Figure C-6 . It should be understood that the rigid attachment is modeled by its footprint only and thus appears two-dimensional in the model. The rigid beams will force the attachment or stiffener footprint at the clamp body to maintain its original shape. A rigid attachment or stiffener should be used only in those cases when the attachment or stiffener stiffness is large relative to that of the clamp. The advantage of using the rigid attachment or stiffener option is that the speed of the finite element analysis can be increased since fewer elements are required to model the attachment or stiffener.

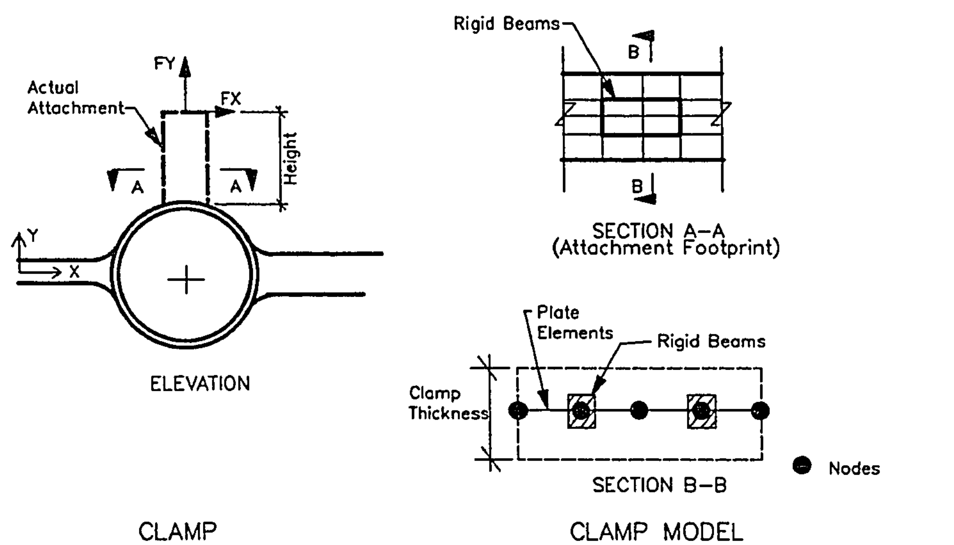


FIGURE C-6 RIGID ATTACHMENT OR STIFFENER

A flexible attachment is modeled with a series of quad plates and beam elements as shown in Figure C-7. The height of the attachment and dimensions of the plate elements are specified by the user. Varying these data changes the stiffness of the attachment. This allows the clamp body to deform beneath the attachment depending on the attachment's rigidity.

Since loads are applied to the top edge of the attachment, a series of rigid beam elements is generated between the top nodes to control the distribution of the stresses and strains between the top attachment nodes. Without these rigid beams, tremendous amount of local deformation would take place in the attachment at the application point of the load, that in actuality is not present. These beams allow the correct stress (or load) distribution to follow the classical MC/I or P/A stress distribution. Also refer to the Load Application Point section for more information.

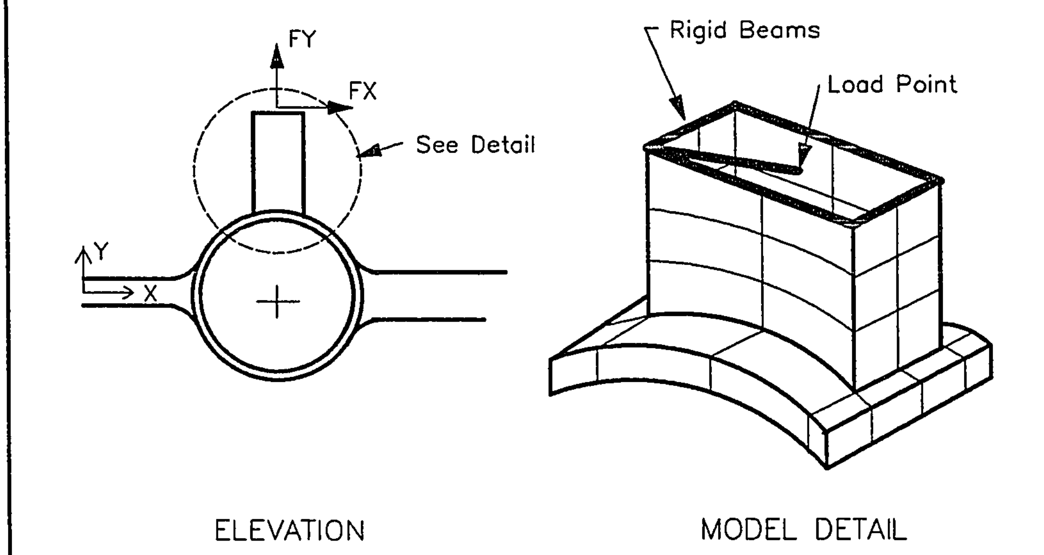


FIGURE C-7 FLEXIBLE ATTACHMENT

Stiffeners are modeled the same as flexible attachments except that the rigid beams are not generated at the top edge of the stiffener, as shown in Figure C-8. Rigid beams are not required since no loads are allowed to be applied through the top of the stiffener.

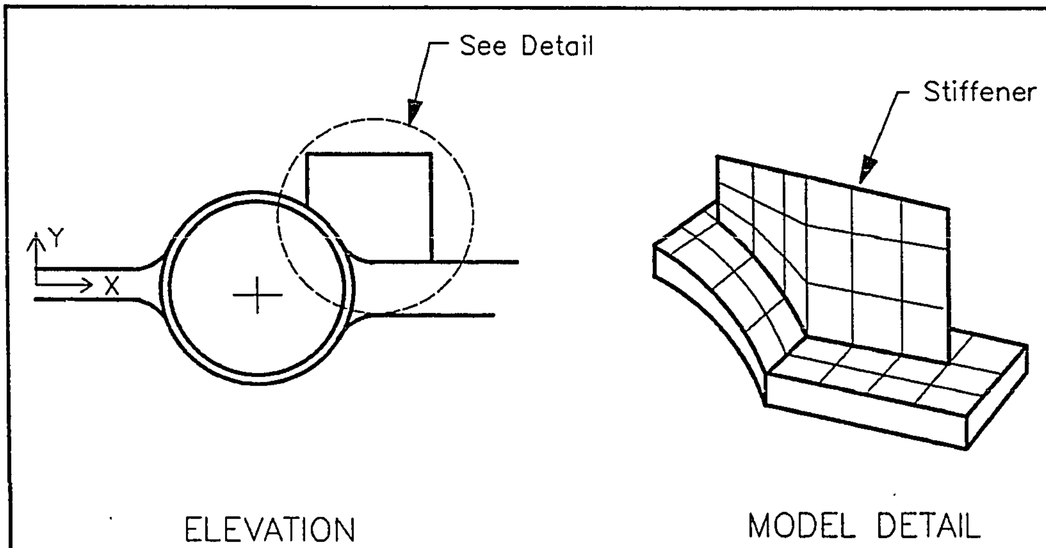


FIGURE C-8 STIFFENER

LOAD APPLICATION POINT

There are two distinct types of load applications available in NuClamp. They are bolt loads and clamp body loads.

Bolt loads are loads that are applied through the bolts as shown in Figure C-9. These loads are assumed to act at the bolt's mid-point node (y=0).

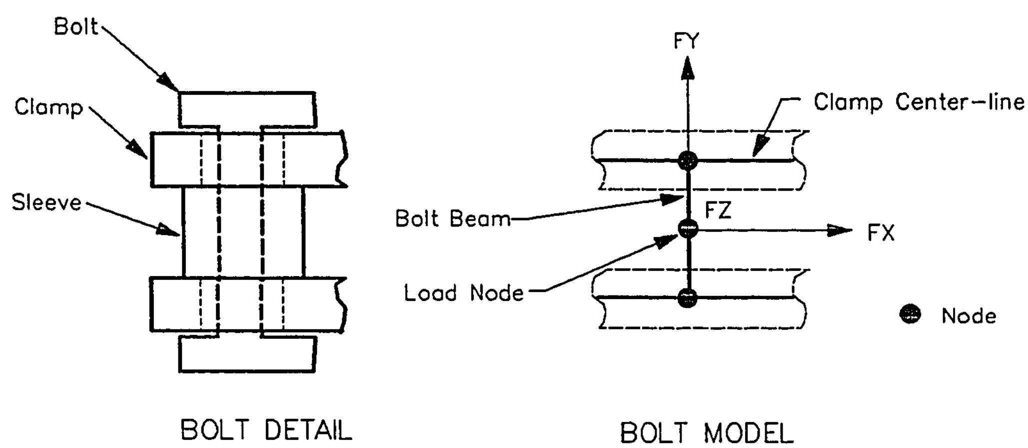


FIGURE C-9 BOLT LOAD APPLICATION POINT

Clamp body loads are modeled by default (DX=DY=DZ= 0.0) as acting on the clamp's surface. The point of application of the clamp body load can be located by taking the global X, Y, and Z coordinates of the reference node and adding the user specified DX, DY, DZ dimensions to each term, respectively (see Figue C-10 and C-11). As discussed earlier, plate elements are two-dimensional elements connected to nodes at the center-line of the clamp. Therefore, the surface of the clamp is one-half plate thickness from the clamp center-line, as shown in Figure C-10. The final Y coordinate of the load application node will also require a term (Teff as shown in Figure C-12) to take into account the effect of the varying effective clamp thickness.

Loads that are applied through the reference node of a flexible load bearing attachment will be transferred from the top of the attachment to the clamp body as shown in Figure C-11. This load path allows the load to be correctly transferred from the attachment to the clamp body.

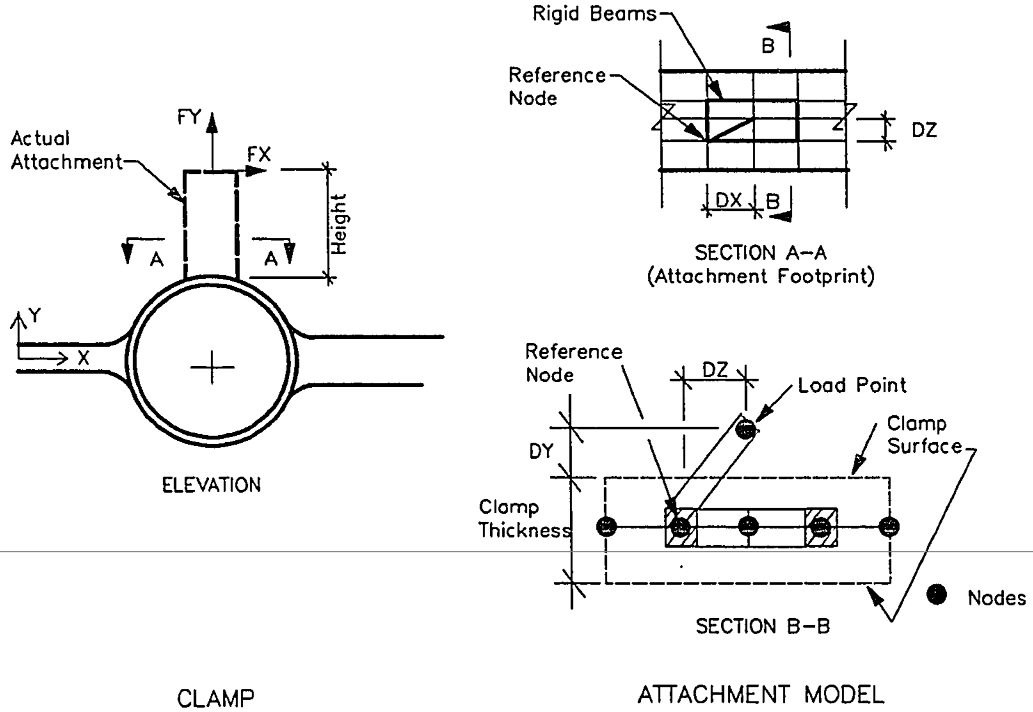


FIGURE C-10 RIGID ATTACHMENT LOAD APPLICATION POINT

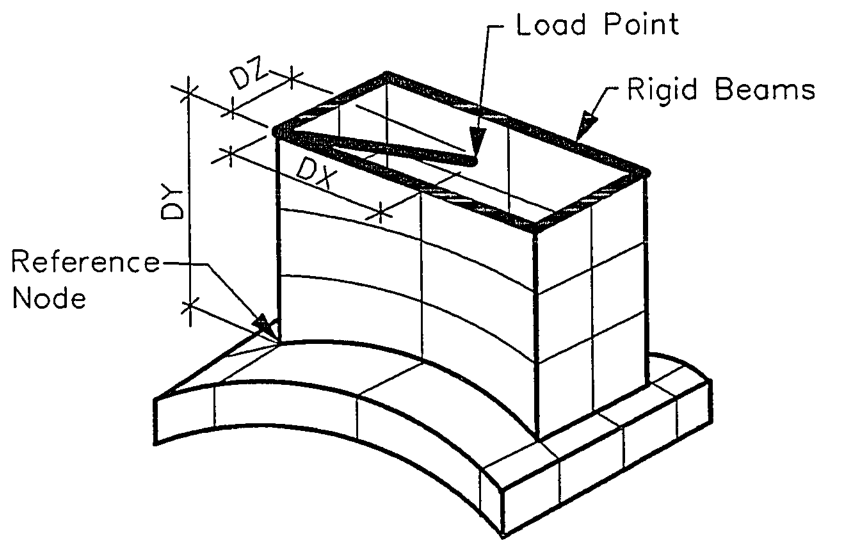


FIGURE C-11 FLEXIBLE ATTACHMENT LOAD APPLICATION POINT

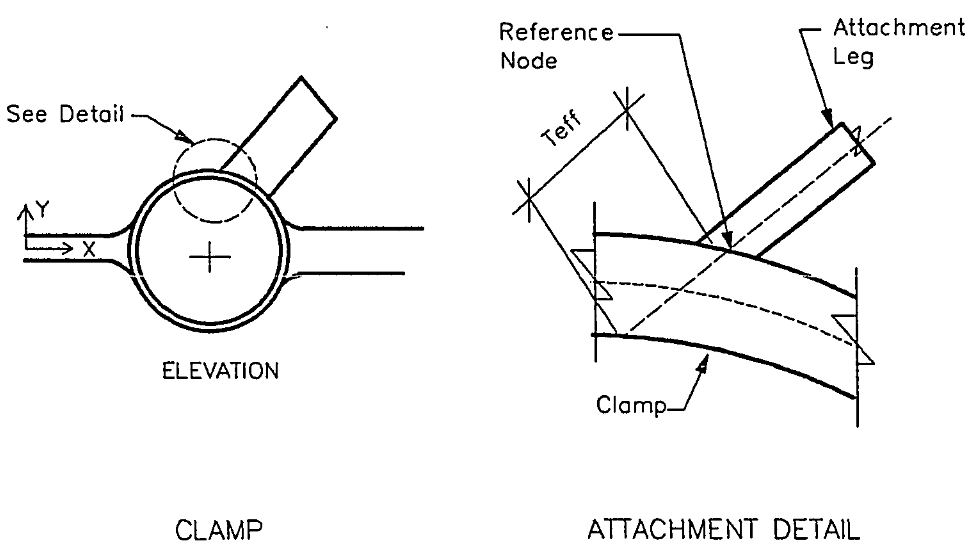


FIGURE C-12 DEFINITION OF Teff

BEAM PROPERTIES

The properties of the three types of beams that are used within NuClamp are summarized in Table 1. The first type is referred to as a rigid beam. Rigid beams are used in the modeling of attachments and for transferring loads. These properties do not make the beam 100% rigid, but relative to the clamp body they provide sufficient rigidity. The second type of beam, referred to as a user defined beam, permits the user to specify a rectangular beam that connects between any two clamp body nodes. The third type of beam is for modeling bolts of diameter D.

TABLE 1[6]

ELEMENT	AREA	TORSION	BENDING Z	BENDING Y
Rigid Beam	100.0	999.0	999.0	999.0
User Beam	WxH	$\beta b d^3$	$\frac{HxW^3}{12}$	$\frac{WxH^3}{12}$
Bolt Beam	$\frac{\pi D^2}{4}$	$\frac{\pi D^4}{32}$	$\frac{\pi D^4}{64}$	$\frac{\pi D^4}{64}$

where:

$b =$ maximum of W and H

$d =$ minimum of W and H

$\beta =$ a constant depending on the $\frac{b}{d}$ ratio

ELEMENT DEFINITION

The elements that have been referenced throughout this thesis are described below with the equivalent ANSYS element name.

ELEMENT	ANSYS EQUIVALENT	DESCRIPTION
Quad Plate	STIF41	This element is a two-dimensional (area) element having membrane (in-plane) stiffness but no bending (out-of-plane) stiffness. It is intended for membrane shell structures and for those structures where bending of

6 Boresi, A. P. and Sidebottom, O. M. (1985) Advanced Mechanics of Materials. John Wiley and Sons, Inc.

		the elements is of secondary importance. The element has three degrees of freedom at each of its four nodes: translations in the local X, Y, and Z directions of the element.
Brick	STIF45	This element is used for the three-dimensional modeling of solid structures. The element is defined by eight nodes having three degrees of freedom each: translations in the local X, Y, and Z directions of the element.
Beam	STIF4	This beam element is defined by two nodes and has tension, compression, torsion, and bending capabilities. The element has six degrees of freedom at each node: translations in the local X, Y, and Z directions and rotations about the X, Y, and Z axes of the element.
Gap	STIF52	This interface element represents two surfaces which may maintain or break physical contact and may slide relative to each other. The element is capable of supporting only compression in the direction normal to the surfaces and shear (Coulomb friction) in the tangential direction. The element has three degrees of freedoms at each node: translations in the local X, Y, and Z directions of the element.

D STANDARD INPUT FORM

NuClamp Input File:______________ ANSYS Input File:______________

Title:

E Mod, Poisson:

Xmax, Zmax, Thk, Space, #Layer, #I, #J, I1, I2, I3, I4, Rad:

Od, Mu, X-Center:

#Bolts:

I-Start, J-Start, I-End, J-End, X, Z, Dia:	I-Start, J-Start, I-End, J-End, X, Z, Dia:

#Control Pts:

I, J, X/Theta, Z:	I, J, X/Theta, Z:	I, J, X/Theta, Z:

#Attachments:

#Seg, Thk, Hgt, Ang, Type, Div:	#Seg, Thk, Hgt, Ang, Type, Div:	#Seg, Thk, Hgt, Ang, Type, Div:

I-Start, J-Start, I-End, J-End:	I-Start, J-Start, I-End, J-End:	I-Start, J-Start, I-End, J-End:

#Beams:

I-Start, J-Start, I-End, J-End, W, H:	I-Start, J-Start, I-End, J-End, W, H:

#Rest:

I, J, Tx, Ty, Tz, Rx, Ry, Rz:	I, J, Tx, Ty, Tz, Rx, Ry, Rz:

#Load Cases:

#Plate Load Points:

I, J, Dx, Dy, Dz:	I, J, Dx, Dy, Dz:	I, J, Dx, Dy, Dz:

Load, Fx, Fy, Fz, Mx, My, Mz: 1: 2: 3:	Load, Fx, Fy, Fz, Mx, My, Mz: 1: 2: 3:	Load, Fx, Fy, Fz, Mx, My, Mz: 1: 2: 3:

#Bolt Load Points:

Bolt No.:	Bolt No.:	Bolt No.:

Load, Fx, Fy, Fz: 1: 2: 3:	Load, Fx, Fy, Fz: 1: 2: 3:	Load, Fx, Fy, Fz: 1: 2: 3:

E GLOSSARY

ASCII file	A computer file that uses the standard ASCII character set.
Bolt load	A load that is applied to the bolt at its mid-point.
Built-up attachment	A member connected to the clamp that is modeled with a series of plate and/or beam elements. Built-up attachments can be either stiffeners or member attachments.
Clamp bend	The section between the clamp ears and the portion of the clamp that surrounds the pipe ($IB1 \leq I \leq IB2$, or $IB3 \leq I \geq IB4$).
Clamp body	The clamp assembly is usually made-up of two pieces of stock steel and bolts. The stock steel is referred to as the clamp body.
Clamp ears	That section of the clamp that is parallel to the global XZ plane ($I \leq IB1$, or $I \leq IB4$).
Control point	NuClamp automatically generates the coordinates of each node; however, the user may over-ride any of these coordinates by using the Control Point option. The user specifies on the Control Point card the new coordinates and the corresponding I,J-line of the node.
Flexible attachment	A built-up attachment that is modeled with a series of plate elements. These plate elements represent the flexibility of the attachment.
I,J-START I,J-END	All points on the clamp can be referenced using the two-dimensional I,J mapping system. Various parameters are specified that connect between two nodes, as with bolts. The user specifies the beginning node (I-START,J-START) and the terminal node (I-END,J-END) of the element.
Member attachment	A structural member that is welded to the clamp body as in the case of a stanchion.
Mesh	A series or group of plate or brick elements.
Plate element	A 4-node quadrilateral, iso-parametric membrane-bending plate element.
Plate load	A load that is applied to the clamp body.
Pre-processor	A program that prepares the required input data for another program (Example: NuClamp prepares input data for ANSYS).
Process pipe	The pipe that the clamp is supporting.
Reference point	The start node generated on the first element of an attachment.

Rigid attachment	A built-up attachment that is modeled with rigid beams. The attachment footprint is so rigid that under any loads the attachment remains plane (no distortion).
Rigid beam	A beam modeled as a rectangular solid section with the properties shown in Appendix C.
Stiffener	A non-load bearing attachment.

APPENDIX B Example Manual

This appendix contains the Example manual.

The manual format is typical of that used in the nuclear industry and is written to be self-contained from the thesis.

NuClamp

Example Manual

Version 1.0

DISCLAIMER OF WARRANTY

Every reasonable effort has been made to provide a comprehensive and flexible computer program. However, the computer program itself and associated documentation are supplied without representation of warranty, expressed or implied, as to their content, accuracy, or freedom from defects or errors.

RECORD OF REVISION	
REVISION	DESCRIPTION
0	Manual Released

LIST OF EFFECTIVE PAGES

PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV
i	0	4-1	0				
ii	0	4-2 thru 24	0				
iii	0						
iv	0						
v	0						
vi	0	5-1	0				
		5-2 thru 14	0				
		6-1	0				
1-1	0						
1-2 thru 9	0						
		7-1	0				
2-1	0						
2-2 thru 9	0						
3-1	0						
3-2 thru 11	0						

PREFACE

NuClamp is a pre-processor computer program that can generate the necessary finite element model and input to analyze most standard or non-standard pipe clamps.

NuClamp was developed to provide the user with a tool to perform the finite element analysis of a pipe clamp with minimal user input and training. This was accomplished by constructing an interface between the user and ANSYS (version 4.1) using a model building method that is commonly used in the nuclear power industry. Depending on the clamp's complexity, NuClamp requires approximately 20 lines of input data. NuClamp's input data consists of the clamp's overall dimensions, pipe size, bolt sizes and locations, applied loads, and mesh gradation.

Once the ANSYS file has been generated by NuClamp, the user can modify the ANSYS data file before the actual finite element analysis is performed.

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Table of Figures

EXAMPLE 1- Thin Symmetrical Clamp with Bolt Load

The example problem shown in Figure 1 is a typical two bolt clamp with a 9 kip load applied to the left bolt. The process pipe has an outside diameter of 12 inches and is located at 10-5/8 inches from the left edge of the clamp as shown in Figure 1. The stock size of both clamp halves is 3 inches wide by 1/2 inch thick with an overall length of 21.5 inches. Two 1-1/2 inch diameter bolts are used to connect the two clamp halves.

Since the clamp and loads are symmetrical about the XZ plane, a symmetrical mesh will be used. A total of 76 quad plate elements will be generated to model each clamp body half. Quad plate elements are selected because of the 6 to 1 width to thickness ratio of the clamp cross-section (refer to the discussion on element selection). Because of the manner in which the clamp is loaded through the bolt, it is unlikely that any appreciable out of plane bending (or warpage) across the clamps' width will take place; therefore, the quad plate elements are acceptable.

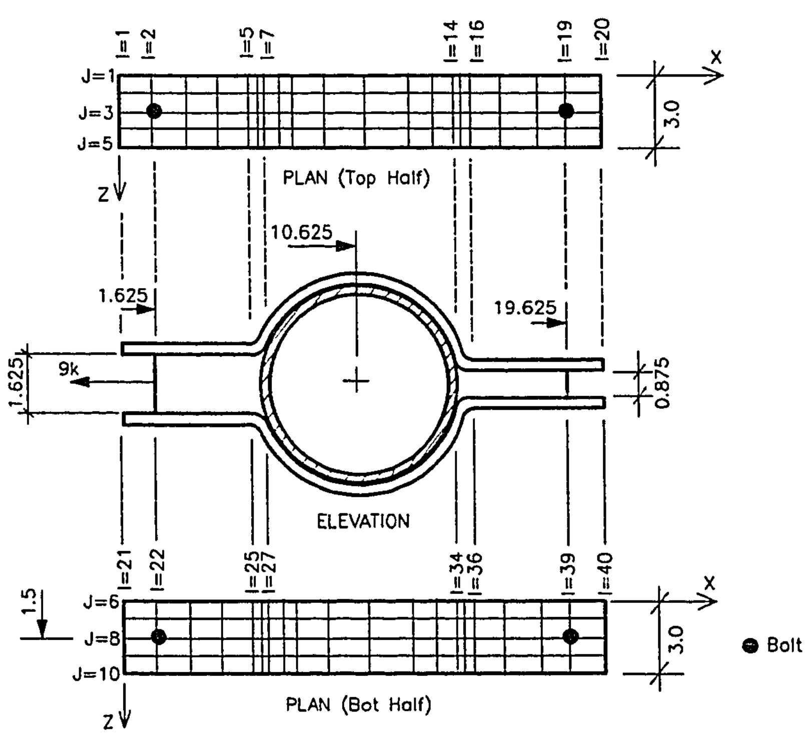

FIGURE 1 EXAMPLE 1 MODEL

The NüClamp input required is as follows:

```
#BOLT #CTRL    #LC #C-PT #B-PT #BEAM  #ATT #REST
    2     0      1     0     1     0     0     0
TITLE:
TEST1
MATERIAL PROPERTIES:-----------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        29000.             .200
DIMENSIONS:--------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4     RAD
 21.500  3.000   .500  1.625      0 20  5   5   7  14  16  1.000
 21.500  3.000   .500   .875      0 20  5  25  27  34  36  1.000
PIPE DATA:---------------------------------------------------------------
    OD     MU X-CENTER
12.000  .000   10.625
BOLT DATA:---------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
      2       3      22       8  1.625   1.500   1.500
     19       3      39       8 19.625   1.500   1.500
BOLT LOAD DATA:----------------------------------------------------------
LOAD BOLT#
  1
LC#      FX       FY       FZ
  1      -9.      0.       0.
```

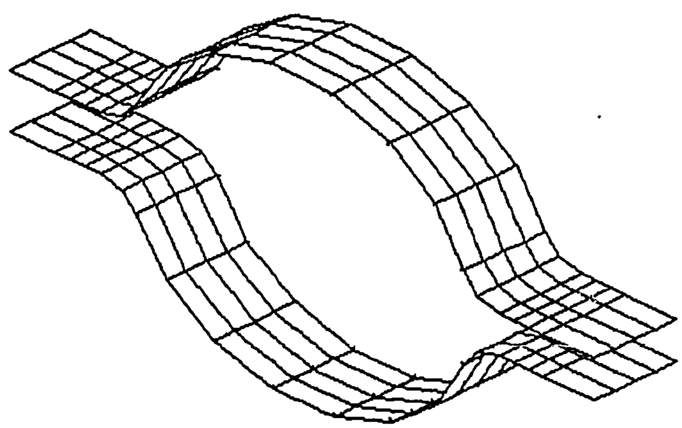

FIGURE 2 EXAMPLE 1 ANSYS PLOT

The ANSYS input generated by NuClamp is listed below. For a description on the various ANSYS input keywords and parameters, refer to the ANSYS User's Manual version 4.1.

```
/PREP7
/TITLE TEST1
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.490,   2.313, 0.0
LOCAL, 13, 1,  17.870,   1.938, 0.0
LOCAL, 14, 1,   3.490,  -2.313, 0.0
LOCAL, 15, 1,  17.870,  -1.938, 0.0
CSYS, 0
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N,   2,     .000,   1.063,     .750
N,   3,     .000,   1.063,    1.500
N,   4,     .000,   1.063,    2.250
N,   5,     .000,   1.063,    3.000
N,   6,    1.625,   1.063,     .000
N,   7,    1.625,   1.063,     .750
N,   8,    1.625,   1.063,    1.500
N,   9,    1.625,   1.063,    2.250
N,  10,    1.625,   1.063,    3.000
N,  11,    2.247,   1.063,     .000
N,  12,    2.247,   1.063,     .750
N,  13,    2.247,   1.063,    1.500
N,  14,    2.247,   1.063,    2.250
N,  15,    2.247,   1.063,    3.000
N,  16,    2.869,   1.063,     .000
N,  17,    2.869,   1.063,     .750
N,  18,    2.869,   1.063,    1.500
N,  19,    2.869,   1.063,    2.250
N,  20,    2.869,   1.063,    3.000
N,  21,    3.490,   1.063,     .000
N,  22,    3.490,   1.063,     .750
N,  23,    3.490,   1.063,    1.500
N,  24,    3.490,   1.063,    2.250
N,  25,    3.490,   1.063,    3.000
N,  76,   17.870,    .688,     .000
```

```
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N,  79,  17.870,    .688,   2.250
N,  80,  17.870,    .688,   3.000
N,  81,  18.455,    .688,    .000
N,  82,  18.455,    .688,    .750
N,  83,  18.455,    .688,   1.500
N,  84,  18.455,    .688,   2.250
N,  85,  18.455,    .688,   3.000
N,  86,  19.040,    .688,    .000
N,  87,  19.040,    .688,    .750
N,  88,  19.040,    .688,   1.500
N,  89,  19.040,    .688,   2.250
N,  90,  19.040,    .688,   3.000
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N,  92,  19.625,    .688,    .750
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N,  95,  19.625,    .688,   3.000
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N, 102,    .000,  -1.063,    .750
N, 103,    .000,  -1.063,   1.500
N, 104,    .000,  -1.063,   2.250
N, 105,    .000,  -1.063,   3.000
N, 106,   1.625,  -1.063,    .000
N, 107,   1.625,  -1.063,    .750
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N, 109,   1.625,  -1.063,   2.250
N, 110,   1.625,  -1.063,   3.000
N, 111,   2.247,  -1.063,    .000
N, 112,   2.247,  -1.063,    .750
N, 113,   2.247,  -1.063,   1.500
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```

```
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N, 125,   3.490,  -1.063,   3.000
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N, 177,  17.870,   -.688,    .750
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N, 179,  17.870,   -.688,   2.250
N, 180,  17.870,   -.688,   3.000
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N, 182,  18.455,   -.688,    .750
N, 183,  18.455,   -.688,   1.500
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N, 188,  19.040,   -.688,   1.500
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N, 190,  19.040,   -.688,   3.000
N, 191,  19.625,   -.688,    .000
N, 192,  19.625,   -.688,    .750
N, 193,  19.625,   -.688,   1.500
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N, 195,  19.625,   -.688,   3.000
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CSYS, 11
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N,  36,   6.250, 141.031,    .000
N,  37,   6.250, 141.031,    .750
N,  38,   6.250, 141.031,   1.500
N,  39,   6.250, 141.031,   2.250
N,  40,   6.250, 141.031,   3.000
N,  41,   6.250, 120.021,    .000
N,  42,   6.250, 120.021,    .750
N,  43,   6.250, 120.021,   1.500
N,  44,   6.250, 120.021,   2.250
N,  45,   6.250, 120.021,   3.000
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N,  47,   6.250,  99.011,    .750
```

N,	48,	6.250,	99.011,	1.500
N,	49,	6.250,	99.011,	2.250
N,	50,	6.250,	99.011,	3.000
N,	51,	6.250,	78.001,	.000
N,	52,	6.250,	78.001,	.750
N,	53,	6.250,	78.001,	1.500
N,	54,	6.250,	78.001,	2.250
N,	55,	6.250,	78.001,	3.000
N,	56,	6.250,	56.991,	.000
N,	57,	6.250,	56.991,	.750
N,	58,	6.250,	56.991,	1.500
N,	59,	6.250,	56.991,	2.250
N,	60,	6.250,	56.991,	3.000
N,	61,	6.250,	35.981,	.000
N,	62,	6.250,	35.981,	.750
N,	63,	6.250,	35.981,	1.500
N,	64,	6.250,	35.981,	2.250
N,	65,	6.250,	35.981,	3.000
N,	66,	6.250,	14.971,	.000
N,	67,	6.250,	14.971,	.750
N,	68,	6.250,	14.971,	1.500
N,	69,	6.250,	14.971,	2.250
N,	70,	6.250,	14.971,	3.000
N,	131,	6.250,	-162.041,	.000
N,	132,	6.250,	-162.041,	.750
N,	133,	6.250,	-162.041,	1.500
N,	134,	6.250,	-162.041,	2.250
N,	135,	6.250,	-162.041,	3.000
N,	136,	6.250,	-141.031,	.000
N,	137,	6.250,	-141.031,	.750
N,	138,	6.250,	-141.031,	1.500
N,	139,	6.250,	-141.031,	2.250
N,	140,	6.250,	-141.031,	3.000
N,	141,	6.250,	-120.021,	.000
N,	142,	6.250,	-120.021,	.750
N,	143,	6.250,	-120.021,	1.500
N,	144,	6.250,	-120.021,	2.250
N,	145,	6.250,	-120.021,	3.000
N,	146,	6.250,	-99.011,	.000
N,	147,	6.250,	-99.011,	.750
N,	148,	6.250,	-99.011,	1.500
N,	149,	6.250,	-99.011,	2.250
N,	150,	6.250,	-99.011,	3.000
N,	151,	6.250,	-78.001,	.000
N,	152,	6.250,	-78.001,	.750
N,	153,	6.250,	-78.001,	1.500

```
N,  154,    6.250,  -78.001,    2.250
N,  155,    6.250,  -78.001,    3.000
N,  156,    6.250,  -56.991,     .000
N,  157,    6.250,  -56.991,     .750
N,  158,    6.250,  -56.991,    1.500
N,  159,    6.250,  -56.991,    2.250
N,  160,    6.250,  -56.991,    3.000
N,  161,    6.250,  -35.981,     .000
N,  162,    6.250,  -35.981,     .750
N,  163,    6.250,  -35.981,    1.500
N,  164,    6.250,  -35.981,    2.250
N,  165,    6.250,  -35.981,    3.000
N,  166,    6.250,  -14.971,     .000
N,  167,    6.250,  -14.971,     .750
N,  168,    6.250,  -14.971,    1.500
N,  169,    6.250,  -14.971,    2.250
N,  170,    6.250,  -14.971,    3.000
CSYS, 12
N,   26,    1.250,  -53.979,     .000
N,   27,    1.250,  -53.979,     .750
N,   28,    1.250,  -53.979,    1.500
N,   29,    1.250,  -53.979,    2.250
N,   30,    1.250,  -53.979,    3.000
CSYS, 13
N,   71,    1.250, -127.514,     .000
N,   72,    1.250, -127.514,     .750
N,   73,    1.250, -127.514,    1.500
N,   74,    1.250, -127.514,    2.250
N,   75,    1.250, -127.514,    3.000
CSYS, 14
N,  126,    1.250,   53.979,     .000
N,  127,    1.250,   53.979,     .750
N,  128,    1.250,   53.979,    1.500
N,  129,    1.250,   53.979,    2.250
N,  130,    1.250,   53.979,    3.000
CSYS, 15
N,  171,    1.250,  127.514,     .000
N,  172,    1.250,  127.514,     .750
N,  173,    1.250,  127.514,    1.500
N,  174,    1.250,  127.514,    2.250
N,  175,    1.250,  127.514,    3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  202,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   33,   68,    5, -.1000,  .0000,  .0000
```

```
NGEN ,    2,  202,   34,   69,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS, 0
N, 201,    1.625,     .000,    1.500
N, 202,   19.625,     .000,    1.500
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .500
REAL, 1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .500
REAL, 2
E, 101,  102,  107,  106
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R, 3, 10.0
REAL, 3
E, 233,  31
EGEN,   8,   5, 153, 153,   1
EGEN,   5,   1, 153, 160,   1
E, 333, 131
EGEN,   8,   5, 193, 193,   1
EGEN,   5,   1, 193, 200,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  4,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,  4
E ,    8,  201
E ,  201,  108
E ,   93,  202
```

```
E , 202,  193
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  233, ALL, 0.0,, 268,   5
D,  234, ALL, 0.0,, 269,   5
D,  235, ALL, 0.0,, 270,   5
D,  236, ALL, 0.0,, 271,   5
D,  237, ALL, 0.0,, 272,   5
D,  333, ALL, 0.0,, 368,   5
D,  334, ALL, 0.0,, 369,   5
D,  335, ALL, 0.0,, 370,   5
D,  336, ALL, 0.0,, 371,   5
D,  337, ALL, 0.0,, 372,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  201,FX,      -9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

EXAMPLE 2- Thick Symmetrical Clamp with Bolt Load

The example problem shown in Figure 3 is geometrically identical to example 1 except the clamp thickness is three-quarters of an inch. As with example 1, this is a typical two bolt clamp with a 9 kip load applied to the left bolt. The process pipe has an outside diameter of 12 inches and is located at 10-5/8 inches from the left edge of the clamp as shown in Figure 3. The stock size of both clamp halves is 3 inches wide by 3/4 inch thick with an overall length of 21.5 inches. Two 1-1/2 inch diameter bolts are used to connect the two clamp halves.

Since the clamp and loads are symmetrical about the XZ plane, a symmetrical mesh will be used. A total of 76 brick elements will be generated to model each clamp body half. Brick elements are selected because of the 4 to 1 width to thickness ratio of the clamp cross-section (refer to the discussion on element selection). Because of the manner in which the clamp is loaded through the bolt, it is unlikely that any appreciable out of plane bending (or warpage) across the clamps' width will take place; therefore, only one layer of brick elements will be required.

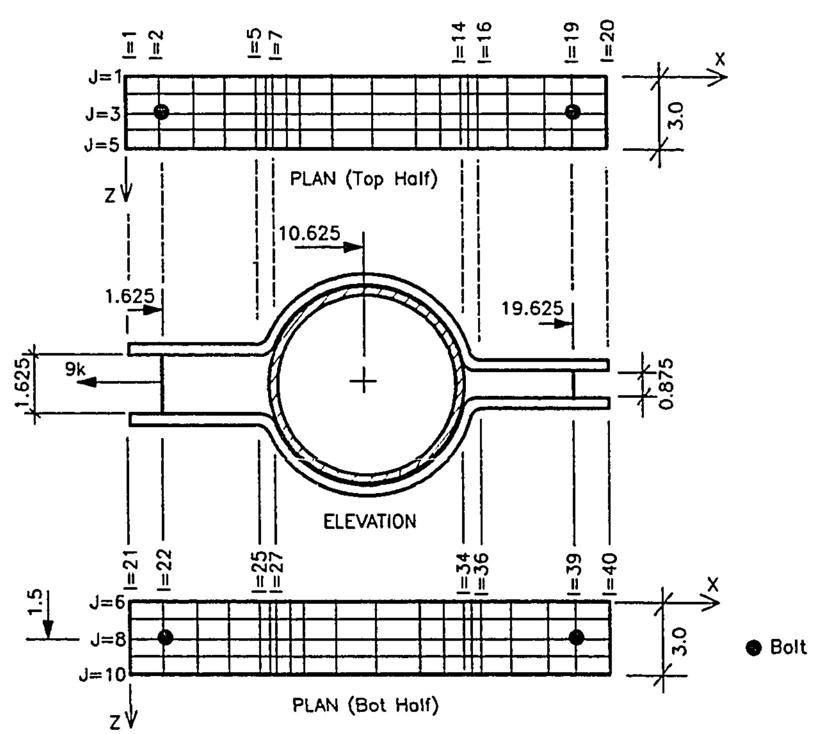

FIGURE 3 EXAMPLE 2 MODEL

The NuClamp input required is as follows:

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2     0     1     0     1     0     0     0
 TITLE:
 TEST7
 MATERIAL PROPERTIES:-----------------------------------------------------
 YOUNG'S MODULUS  POISSON'S RATIO
         30000.             .300
 DIMENSIONS:--------------------------------------------------------------
    XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
  21.500  3.000   .750  1.625      1 20  5   5   7  14  16  1.000
  21.500  3.000   .750   .875      1 20  5  25  27  34  36  1.000
 PIPE DATA:---------------------------------------------------------------
     OD     MU X-CENTER
 12.000   .000   10.625
 BOLT DATA:---------------------------------------------------------------
 I-START J-START   I-END   J-END      X      Z     DIA
       2       3      22       8  1.625  1.500   1.500
      19       3      39       8 19.625  1.500   1.500
 BOLT LOAD DATA:----------------------------------------------------------
 LOAD BOLT#
   1
 LC#      FX       FY       FZ
   1      -9.      0.       0.
```

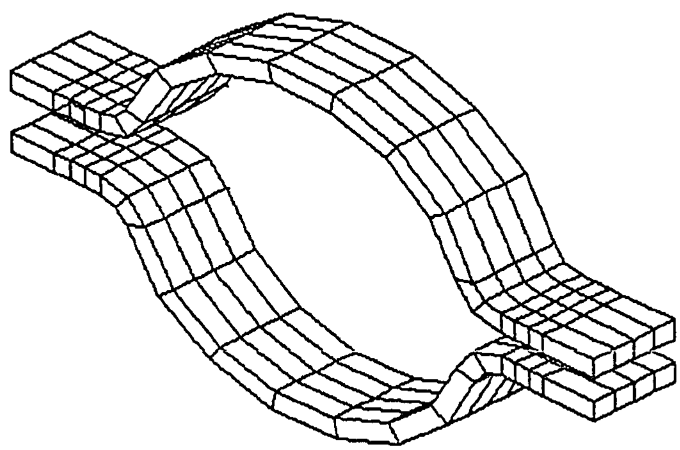

FIGURE 4 EXAMPLE 2 ANSYS PLOT

The ANSYS input generated by NuClamp is listed below. For a description on the various ANSYS input keywords and parameters, refer to the ANSYS User's Manual version 4.1.

```
/PREP7
/TITLE TEST7
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,      30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,     .813,     .000
N,    2,     .000,     .813,     .750
N,    3,     .000,     .813,    1.500
N,    4,     .000,     .813,    2.250
N,    5,     .000,     .813,    3.000
N,    6,    1.625,     .813,     .000
N,    7,    1.625,     .813,     .750
N,    8,    1.625,     .813,    1.500
N,    9,    1.625,     .813,    2.250
N,   10,    1.625,     .813,    3.000
N,   11,    2.187,     .813,     .000
N,   12,    2.187,     .813,     .750
N,   13,    2.187,     .813,    1.500
N,   14,    2.187,     .813,    2.250
N,   15,    2.187,     .813,    3.000
N,   16,    2.749,     .813,     .000
N,   17,    2.749,     .813,     .750
N,   18,    2.749,     .813,    1.500
N,   19,    2.749,     .813,    2.250
N,   20,    2.749,     .813,    3.000
N,   21,    3.311,     .813,     .000
N,   22,    3.311,     .813,     .750
N,   23,    3.311,     .813,    1.500
N,   24,    3.311,     .813,    2.250
N,   25,    3.311,     .813,    3.000
N,   76,   18.060,     .438,     .000
```

```
N,   77,  18.060,    .438,    .750
N,   78,  18.060,    .438,   1.500
N,   79,  18.060,    .438,   2.250
N,   80,  18.060,    .438,   3.000
N,   81,  18.582,    .438,    .000
N,   82,  18.582,    .438,    .750
N,   83,  18.582,    .438,   1.500
N,   84,  18.582,    .438,   2.250
N,   85,  18.582,    .438,   3.000
N,   86,  19.103,    .438,    .000
N,   87,  19.103,    .438,    .750
N,   88,  19.103,    .438,   1.500
N,   89,  19.103,    .438,   2.250
N,   90,  19.103,    .438,   3.000
N,   91,  19.625,    .438,    .000
N,   92,  19.625,    .438,    .750
N,   93,  19.625,    .438,   1.500
N,   94,  19.625,    .438,   2.250
N,   95,  19.625,    .438,   3.000
N,   96,  21.500,    .438,    .000
N,   97,  21.500,    .438,    .750
N,   98,  21.500,    .438,   1.500
N,   99,  21.500,    .438,   2.250
N,  100,  21.500,    .438,   3.000
N,  101,    .000,   -.813,    .000
N,  102,    .000,   -.813,    .750
N,  103,    .000,   -.813,   1.500
N,  104,    .000,   -.813,   2.250
N,  105,    .000,   -.813,   3.000
N,  106,   1.625,   -.813,    .000
N,  107,   1.625,   -.813,    .750
N,  108,   1.625,   -.813,   1.500
N,  109,   1.625,   -.813,   2.250
N,  110,   1.625,   -.813,   3.000
N,  111,   2.187,   -.813,    .000
N,  112,   2.187,   -.813,    .750
N,  113,   2.187,   -.813,   1.500
N,  114,   2.187,   -.813,   2.250
N,  115,   2.187,   -.813,   3.000
N,  116,   2.749,   -.813,    .000
N,  117,   2.749,   -.813,    .750
N,  118,   2.749,   -.813,   1.500
N,  119,   2.749,   -.813,   2.250
N,  120,   2.749,   -.813,   3.000
N,  121,   3.311,   -.813,    .000
N,  122,   3.311,   -.813,    .750
```

```
N,  123,   3.311,   -.813,   1.500
N,  124,   3.311,   -.813,   2.250
N,  125,   3.311,   -.813,   3.000
N,  176,  18.060,   -.438,    .000
N,  177,  18.060,   -.438,    .750
N,  178,  18.060,   -.438,   1.500
N,  179,  18.060,   -.438,   2.250
N,  180,  18.060,   -.438,   3.000
N,  181,  18.582,   -.438,    .000
N,  182,  18.582,   -.438,    .750
N,  183,  18.582,   -.438,   1.500
N,  184,  18.582,   -.438,   2.250
N,  185,  18.582,   -.438,   3.000
N,  186,  19.103,   -.438,    .000
N,  187,  19.103,   -.438,    .750
N,  188,  19.103,   -.438,   1.500
N,  189,  19.103,   -.438,   2.250
N,  190,  19.103,   -.438,   3.000
N,  191,  19.625,   -.438,    .000
N,  192,  19.625,   -.438,    .750
N,  193,  19.625,   -.438,   1.500
N,  194,  19.625,   -.438,   2.250
N,  195,  19.625,   -.438,   3.000
N,  196,  21.500,   -.438,    .000
N,  197,  21.500,   -.438,    .750
N,  198,  21.500,   -.438,   1.500
N,  199,  21.500,   -.438,   2.250
N,  200,  21.500,   -.438,   3.000
CSYS, 11
N,   31,   6.000, 160.692,    .000
N,   32,   6.000, 160.692,    .750
N,   33,   6.000, 160.692,   1.500
N,   34,   6.000, 160.692,   2.250
N,   35,   6.000, 160.692,   3.000
N,   36,   6.000, 140.078,    .000
N,   37,   6.000, 140.078,    .750
N,   38,   6.000, 140.078,   1.500
N,   39,   6.000, 140.078,   2.250
N,   40,   6.000, 140.078,   3.000
N,   41,   6.000, 119.464,    .000
N,   42,   6.000, 119.464,    .750
N,   43,   6.000, 119.464,   1.500
N,   44,   6.000, 119.464,   2.250
N,   45,   6.000, 119.464,   3.000
N,   46,   6.000,  98.850,    .000
N,   47,   6.000,  98.850,    .750
```

```
N,  48,   6.000,   98.850,   1.500
N,  49,   6.000,   98.850,   2.250
N,  50,   6.000,   98.850,   3.000
N,  51,   6.000,   78.237,    .000
N,  52,   6.000,   78.237,    .750
N,  53,   6.000,   78.237,   1.500
N,  54,   6.000,   78.237,   2.250
N,  55,   6.000,   78.237,   3.000
N,  56,   6.000,   57.623,    .000
N,  57,   6.000,   57.623,    .750
N,  58,   6.000,   57.623,   1.500
N,  59,   6.000,   57.623,   2.250
N,  60,   6.000,   57.623,   3.000
N,  61,   6.000,   37.009,    .000
N,  62,   6.000,   37.009,    .750
N,  63,   6.000,   37.009,   1.500
N,  64,   6.000,   37.009,   2.250
N,  65,   6.000,   37.009,   3.000
N,  66,   6.000,   16.395,    .000
N,  67,   6.000,   16.395,    .750
N,  68,   6.000,   16.395,   1.500
N,  69,   6.000,   16.395,   2.250
N,  70,   6.000,   16.395,   3.000
N, 131,   6.000, -160.692,    .000
N, 132,   6.000, -160.692,    .750
N, 133,   6.000, -160.692,   1.500
N, 134,   6.000, -160.692,   2.250
N, 135,   6.000, -160.692,   3.000
N, 136,   6.000, -140.078,    .000
N, 137,   6.000, -140.078,    .750
N, 138,   6.000, -140.078,   1.500
N, 139,   6.000, -140.078,   2.250
N, 140,   6.000, -140.078,   3.000
N, 141,   6.000, -119.464,    .000
N, 142,   6.000, -119.464,    .750
N, 143,   6.000, -119.464,   1.500
N, 144,   6.000, -119.464,   2.250
N, 145,   6.000, -119.464,   3.000
N, 146,   6.000,  -98.850,    .000
N, 147,   6.000,  -98.850,    .750
N, 148,   6.000,  -98.850,   1.500
N, 149,   6.000,  -98.850,   2.250
N, 150,   6.000,  -98.850,   3.000
N, 151,   6.000,  -78.237,    .000
N, 152,   6.000,  -78.237,    .750
N, 153,   6.000,  -78.237,   1.500
```

```
N,  154,   6.000,  -78.237,   2.250
N,  155,   6.000,  -78.237,   3.000
N,  156,   6.000,  -57.623,    .000
N,  157,   6.000,  -57.623,    .750
N,  158,   6.000,  -57.623,   1.500
N,  159,   6.000,  -57.623,   2.250
N,  160,   6.000,  -57.623,   3.000
N,  161,   6.000,  -37.009,    .000
N,  162,   6.000,  -37.009,    .750
N,  163,   6.000,  -37.009,   1.500
N,  164,   6.000,  -37.009,   2.250
N,  165,   6.000,  -37.009,   3.000
N,  166,   6.000,  -16.395,    .000
N,  167,   6.000,  -16.395,    .750
N,  168,   6.000,  -16.395,   1.500
N,  169,   6.000,  -16.395,   2.250
N,  170,   6.000,  -16.395,   3.000
CSYS, 12
N,   26,   1.750,  -54.654,    .000
N,   27,   1.750,  -54.654,    .750
N,   28,   1.750,  -54.654,   1.500
N,   29,   1.750,  -54.654,   2.250
N,   30,   1.750,  -54.654,   3.000
CSYS, 13
N,   71,   1.750, -126.802,    .000
N,   72,   1.750, -126.802,    .750
N,   73,   1.750, -126.802,   1.500
N,   74,   1.750, -126.802,   2.250
N,   75,   1.750, -126.802,   3.000
CSYS, 14
N,  126,   1.750,   54.654,    .000
N,  127,   1.750,   54.654,    .750
N,  128,   1.750,   54.654,   1.500
N,  129,   1.750,   54.654,   2.250
N,  130,   1.750,   54.654,   3.000
CSYS, 15
N,  171,   1.750,  126.802,    .000
N,  172,   1.750,  126.802,    .750
N,  173,   1.750,  126.802,   1.500
N,  174,   1.750,  126.802,   2.250
N,  175,   1.750,  126.802,   3.000
CSYS,  0
NGEN ,   2,  200,    1,   25,    1,  .0000,  .7500,  .0000
CSYS, 12
NGEN ,   2,  200,   26,   30,    1, -.7500,  .0000,  .0000
CSYS, 11
```

```
NGEN ,    2,  200,   31,   70,    1,  .7500,  .0000,  .0000
CSYS, 13
NGEN ,    2,  200,   71,   75,    1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2,  200,   76,  100,    1,  .0000,  .7500,  .0000
CSYS,  0
NGEN ,    2,  200,  101,  125,    1,  .0000, -.7500,  .0000
CSYS, 14
NGEN ,    2,  200,  126,  130,    1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,    2,  200,  131,  170,    1,  .7500,  .0000,  .0000
CSYS, 15
NGEN ,    2,  200,  171,  175,    1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2,  200,  176,  200,    1,  .0000, -.7500,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  402,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,   34,   69,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2,  402,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  401,    1.625,     .000,    1.500
N,  402,   19.625,     .000,    1.500
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,    1,    2,    7,    6,  201,  202,  207,  206
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E,  101,  102,  107,  106,  301,  302,  307,  306
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  1, 10.0
REAL,  1
```

```
E, 433,  31
EGEN,   8,   5, 153, 153,   1
EGEN,   5,   1, 153, 160,   1
E, 533, 131
EGEN,   8,   5, 193, 193,   1
EGEN,   5,   1, 193, 200,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   2,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,   2
E ,    8,  401
E ,  401,  108
E ,   93,  402
E ,  402,  193
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  433, ALL, 0.0,, 468,   5
D,  434, ALL, 0.0,, 469,   5
D,  435, ALL, 0.0,, 470,   5
D,  436, ALL, 0.0,, 471,   5
D,  437, ALL, 0.0,, 472,   5
D,  533, ALL, 0.0,, 568,   5
D,  534, ALL, 0.0,, 569,   5
D,  535, ALL, 0.0,, 570,   5
D,  536, ALL, 0.0,, 571,   5
D,  537, ALL, 0.0,, 572,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  401,FX,       -9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

EXAMPLE 3- Thin Symmetrical Clamp with Bolt Load and User Beams

The example problem shown in Figure 5 is geometrically identical to example 1 except that 8 beams have been added to stiffen and strengthen the clamp. There are two load cases for this clamp. The first is the 9 kip load applied to the left bolt as seen in example 1 and 2. The second load case consists of two bolt loads: the 9 kip load applied to the left bolt and an additional 1 kip load applied to the same bolt in the Z direction. The process pipe has an outside diameter of 12 inches and is located at 10-5/8 inches from the left edge of the clamp as shown in Figure 5. The stock size of both clamp halves is 3 inches wide by 1/2 inch thick with an overall length of 21.5 inches. Two 1-1/2 inch diameter bolts are used to connect the two clamp halves.

Since the clamp and loads are symmetrical about the XZ plane, a symmetrical mesh will also be used. A total of 76 quad plate elements will be generated to model each clamp body half. Quad plate elements are selected because of the 6 to 1 width to thickness ratio of the clamp cross-section (refer to the discussion on element selection). Because of the method in which the clamp is loaded through the bolt, it is unlikely that any appreciable out of plane bending (or warpage) across the clamps' width will take place, therefore, the quad plate elements are acceptable. In order to take advantage of the friction between the pipe and clamp, the coefficient of friction, MU, is set to 0.15.

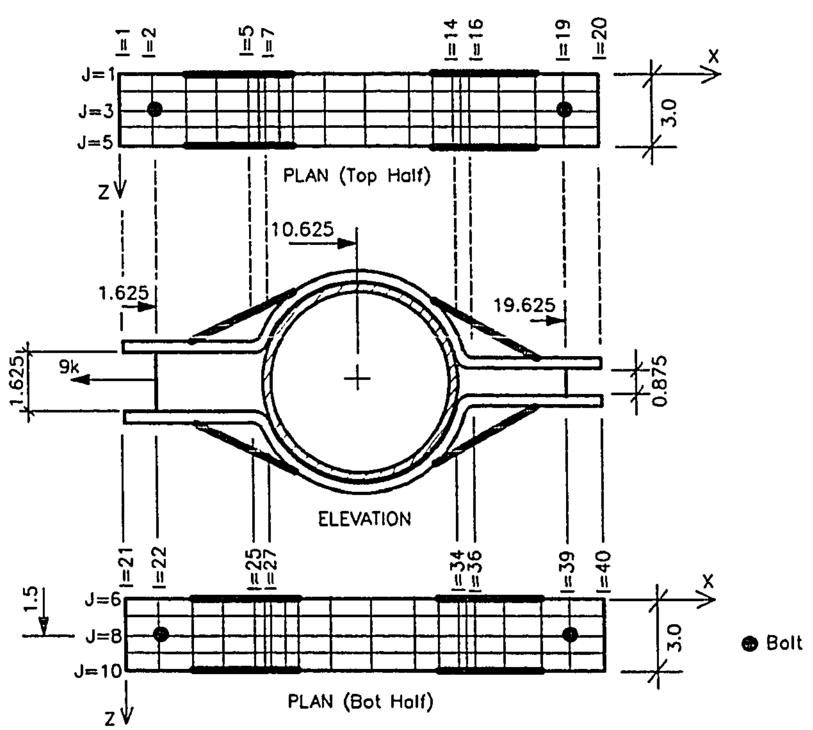

FIGURE 5 EXAMPLE 3 MODEL

The NuClamp input required is as follows:

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2     0     2     0     1     8     0     0
TITLE:
Example 3
MATERIAL PROPERTIES:-----------------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        29999.            .340
DIMENSIONS:-------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I  #J IB1 IB2 IB3 IB4    RAD
 21.500  3.000   .750  1.625      0 20  5   5   7  14  16  1.000
 21.500  3.000   .750   .875      0 20  5  25  27  34  36  1.000
PIPE DATA:--------------------------------------------------------------
    OD     MU X-CENTER
12.000  .150   10.625
BOLT DATA:--------------------------------------------------------------
I-START J-START   I-END   J-END       X       Z      DIA
      2       3      22       8   1.625   1.500    1.500
     19       3      39       8  19.625   1.500    1.500
BEAM DATA:--------------------------------------------------------------
 I-START J-START   I-END   J-END       W       H
       3       1       9       1   1.100   1.200
       3       5       9       5   1.100   1.200
      23       6      29       6   2.100   2.200
      23      10      29      10   2.300   2.400
      18       1      13       1   2.500   2.400
      18       5      13       5   2.900   2.800
      38       6      33       6   1.100   1.200
      38      10      33      10   1.100   1.200
BOLT LOAD DATA:----------------------------------------------------------
LOAD BOLT#
  1
LC#        FX          FY          FZ
  1    -9.000        .000        .000
  2    -9.000        .000       1.000
```

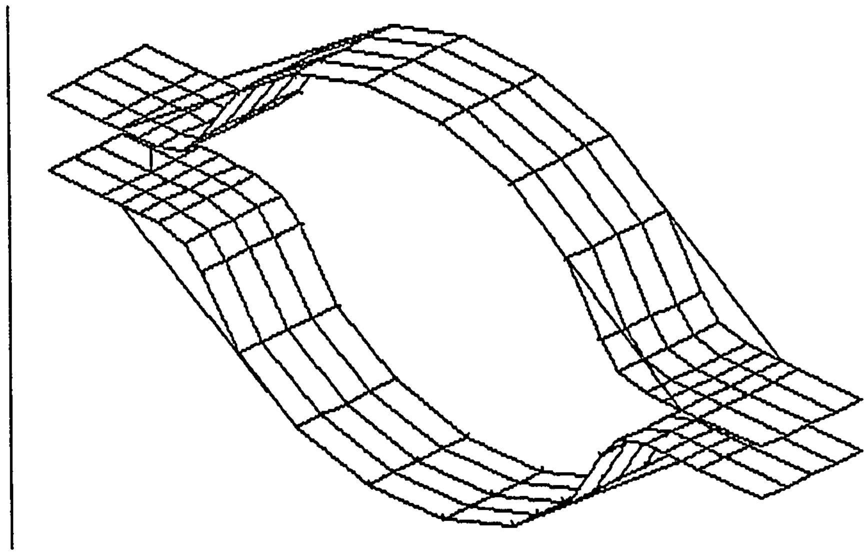

FIGURE 6 EXAMPLE PLOT

The ANSYS input generated by NuClamp is listed below. For a description on the various ANSYS input keywords and parameters, refer to the ANSYS User's Manual version 4.1.

```
/PREP7
/TITLE Example 3
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     29999.000
NUXY, 1,  .340
MU, 2,  .150
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,    1.188,     .000
N,    2,     .000,    1.188,     .750
N,    3,     .000,    1.188,    1.500
N,    4,     .000,    1.188,    2.250
N,    5,     .000,    1.188,    3.000
N,    6,    1.625,    1.188,     .000
N,    7,    1.625,    1.188,     .750
N,    8,    1.625,    1.188,    1.500
N,    9,    1.625,    1.188,    2.250
N,   10,    1.625,    1.188,    3.000
N,   11,    2.187,    1.188,     .000
N,   12,    2.187,    1.188,     .750
N,   13,    2.187,    1.188,    1.500
N,   14,    2.187,    1.188,    2.250
N,   15,    2.187,    1.188,    3.000
N,   16,    2.749,    1.188,     .000
N,   17,    2.749,    1.188,     .750
N,   18,    2.749,    1.188,    1.500
N,   19,    2.749,    1.188,    2.250
N,   20,    2.749,    1.188,    3.000
N,   21,    3.311,    1.188,     .000
N,   22,    3.311,    1.188,     .750
N,   23,    3.311,    1.188,    1.500
N,   24,    3.311,    1.188,    2.250
N,   25,    3.311,    1.188,    3.000
N,   76,   18.060,     .813,     .000
```

```
N,   77,  18.060,    .813,    .750
N,   78,  18.060,    .813,   1.500
N,   79,  18.060,    .813,   2.250
N,   80,  18.060,    .813,   3.000
N,   81,  18.582,    .813,    .000
N,   82,  18.582,    .813,    .750
N,   83,  18.582,    .813,   1.500
N,   84,  18.582,    .813,   2.250
N,   85,  18.582,    .813,   3.000
N,   86,  19.103,    .813,    .000
N,   87,  19.103,    .813,    .750
N,   88,  19.103,    .813,   1.500
N,   89,  19.103,    .813,   2.250
N,   90,  19.103,    .813,   3.000
N,   91,  19.625,    .813,    .000
N,   92,  19.625,    .813,    .750
N,   93,  19.625,    .813,   1.500
N,   94,  19.625,    .813,   2.250
N,   95,  19.625,    .813,   3.000
N,   96,  21.500,    .813,    .000
N,   97,  21.500,    .813,    .750
N,   98,  21.500,    .813,   1.500
N,   99,  21.500,    .813,   2.250
N,  100,  21.500,    .813,   3.000
N,  101,    .000,  -1.188,    .000
N,  102,    .000,  -1.188,    .750
N,  103,    .000,  -1.188,   1.500
N,  104,    .000,  -1.188,   2.250
N,  105,    .000,  -1.188,   3.000
N,  106,   1.625,  -1.188,    .000
N,  107,   1.625,  -1.188,    .750
N,  108,   1.625,  -1.188,   1.500
N,  109,   1.625,  -1.188,   2.250
N,  110,   1.625,  -1.188,   3.000
N,  111,   2.187,  -1.188,    .000
N,  112,   2.187,  -1.188,    .750
N,  113,   2.187,  -1.188,   1.500
N,  114,   2.187,  -1.188,   2.250
N,  115,   2.187,  -1.188,   3.000
N,  116,   2.749,  -1.188,    .000
N,  117,   2.749,  -1.188,    .750
N,  118,   2.749,  -1.188,   1.500
N,  119,   2.749,  -1.188,   2.250
N,  120,   2.749,  -1.188,   3.000
N,  121,   3.311,  -1.188,    .000
N,  122,   3.311,  -1.188,    .750
```

```
N,  123,    3.311,   -1.188,    1.500
N,  124,    3.311,   -1.188,    2.250
N,  125,    3.311,   -1.188,    3.000
N,  176,   18.060,    -.813,     .000
N,  177,   18.060,    -.813,     .750
N,  178,   18.060,    -.813,    1.500
N,  179,   18.060,    -.813,    2.250
N,  180,   18.060,    -.813,    3.000
N,  181,   18.582,    -.813,     .000
N,  182,   18.582,    -.813,     .750
N,  183,   18.582,    -.813,    1.500
N,  184,   18.582,    -.813,    2.250
N,  185,   18.582,    -.813,    3.000
N,  186,   19.103,    -.813,     .000
N,  187,   19.103,    -.813,     .750
N,  188,   19.103,    -.813,    1.500
N,  189,   19.103,    -.813,    2.250
N,  190,   19.103,    -.813,    3.000
N,  191,   19.625,    -.813,     .000
N,  192,   19.625,    -.813,     .750
N,  193,   19.625,    -.813,    1.500
N,  194,   19.625,    -.813,    2.250
N,  195,   19.625,    -.813,    3.000
N,  196,   21.500,    -.813,     .000
N,  197,   21.500,    -.813,     .750
N,  198,   21.500,    -.813,    1.500
N,  199,   21.500,    -.813,    2.250
N,  200,   21.500,    -.813,    3.000
CSYS, 11
N,    31,    6.375,  160.692,     .000
N,    32,    6.375,  160.692,     .750
N,    33,    6.375,  160.692,    1.500
N,    34,    6.375,  160.692,    2.250
N,    35,    6.375,  160.692,    3.000
N,    36,    6.375,  140.078,     .000
N,    37,    6.375,  140.078,     .750
N,    38,    6.375,  140.078,    1.500
N,    39,    6.375,  140.078,    2.250
N,    40,    6.375,  140.078,    3.000
N,    41,    6.375,  119.464,     .000
N,    42,    6.375,  119.464,     .750
N,    43,    6.375,  119.464,    1.500
N,    44,    6.375,  119.464,    2.250
N,    45,    6.375,  119.464,    3.000
N,    46,    6.375,   98.850,     .000
N,    47,    6.375,   98.850,     .750
```

```
N,   48,   6.375,   98.850,   1.500
N,   49,   6.375,   98.850,   2.250
N,   50,   6.375,   98.850,   3.000
N,   51,   6.375,   78.237,    .000
N,   52,   6.375,   78.237,    .750
N,   53,   6.375,   78.237,   1.500
N,   54,   6.375,   78.237,   2.250
N,   55,   6.375,   78.237,   3.000
N,   56,   6.375,   57.623,    .000
N,   57,   6.375,   57.623,    .750
N,   58,   6.375,   57.623,   1.500
N,   59,   6.375,   57.623,   2.250
N,   60,   6.375,   57.623,   3.000
N,   61,   6.375,   37.009,    .000
N,   62,   6.375,   37.009,    .750
N,   63,   6.375,   37.009,   1.500
N,   64,   6.375,   37.009,   2.250
N,   65,   6.375,   37.009,   3.000
N,   66,   6.375,   16.395,    .000
N,   67,   6.375,   16.395,    .750
N,   68,   6.375,   16.395,   1.500
N,   69,   6.375,   16.395,   2.250
N,   70,   6.375,   16.395,   3.000
N,  131,   6.375, -160.692,    .000
N,  132,   6.375, -160.692,    .750
N,  133,   6.375, -160.692,   1.500
N,  134,   6.375, -160.692,   2.250
N,  135,   6.375, -160.692,   3.000
N,  136,   6.375, -140.078,    .000
N,  137,   6.375, -140.078,    .750
N,  138,   6.375, -140.078,   1.500
N,  139,   6.375, -140.078,   2.250
N,  140,   6.375, -140.078,   3.000
N,  141,   6.375, -119.464,    .000
N,  142,   6.375, -119.464,    .750
N,  143,   6.375, -119.464,   1.500
N,  144,   6.375, -119.464,   2.250
N,  145,   6.375, -119.464,   3.000
N,  146,   6.375,  -98.850,    .000
N,  147,   6.375,  -98.850,    .750
N,  148,   6.375,  -98.850,   1.500
N,  149,   6.375,  -98.850,   2.250
N,  150,   6.375,  -98.850,   3.000
N,  151,   6.375,  -78.237,    .000
N,  152,   6.375,  -78.237,    .750
N,  153,   6.375,  -78.237,   1.500
```

```
N,  154,   6.375,  -78.237,   2.250
N,  155,   6.375,  -78.237,   3.000
N,  156,   6.375,  -57.623,    .000
N,  157,   6.375,  -57.623,    .750
N,  158,   6.375,  -57.623,   1.500
N,  159,   6.375,  -57.623,   2.250
N,  160,   6.375,  -57.623,   3.000
N,  161,   6.375,  -37.009,    .000
N,  162,   6.375,  -37.009,    .750
N,  163,   6.375,  -37.009,   1.500
N,  164,   6.375,  -37.009,   2.250
N,  165,   6.375,  -37.009,   3.000
N,  166,   6.375,  -16.395,    .000
N,  167,   6.375,  -16.395,    .750
N,  168,   6.375,  -16.395,   1.500
N,  169,   6.375,  -16.395,   2.250
N,  170,   6.375,  -16.395,   3.000
CSYS, 12
N,   26,   1.375,  -54.654,    .000
N,   27,   1.375,  -54.654,    .750
N,   28,   1.375,  -54.654,   1.500
N,   29,   1.375,  -54.654,   2.250
N,   30,   1.375,  -54.654,   3.000
CSYS, 13
N,   71,   1.375, -126.802,    .000
N,   72,   1.375, -126.802,    .750
N,   73,   1.375, -126.802,   1.500
N,   74,   1.375, -126.802,   2.250
N,   75,   1.375, -126.802,   3.000
CSYS, 14
N,  126,   1.375,   54.654,    .000
N,  127,   1.375,   54.654,    .750
N,  128,   1.375,   54.654,   1.500
N,  129,   1.375,   54.654,   2.250
N,  130,   1.375,   54.654,   3.000
CSYS, 15
N,  171,   1.375,  126.802,    .000
N,  172,   1.375,  126.802,    .750
N,  173,   1.375,  126.802,   1.500
N,  174,   1.375,  126.802,   2.250
N,  175,   1.375,  126.802,   3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  202,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   33,   68,    5, -.1000,  .0000,  .0000
```

```
NGEN ,    2, 202,   34,   69,    5, -.1000,  .0000,  .0000
NGEN ,    2, 202,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2, 202,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2, 202,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2, 202,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2, 202,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2, 202,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  201,    1.625,     .000,    1.500
N,  202,   19.625,     .000,    1.500
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .750
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E,  101,  102,  107,  106
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 233,  31
EGEN,   8,   5, 153, 153,   1
EGEN,   5,   1, 153, 160,   1
E, 333, 131
EGEN,   8,   5, 193, 193,   1
EGEN,   5,   1, 193, 200,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   4,    1.3200,     .1331,     .1584,     1.2000,     1.1000,,,     .3131
REAL,   4
E ,   11,   41
E ,   15,   45
R,   5,    4.6200,    1.6978,    1.8634,     2.2000,     2.1000,,,    3.9933
```

```
REAL,   5
E ,  111,  141
R,   6,   5.5200,    2.4334,    2.6496,    2.4000,    2.3000,,,    5.7234
REAL,   6
E ,  115,  145
R,   7,   6.0000,    3.1250,    2.8800,    2.4000,    2.5000,,,    6.7738
REAL,   7
E ,   86,   61
R,   8,   8.1200,    5.6908,    5.3051,    2.8000,    2.9000,,,   12.4775
REAL,   8
E ,   90,   65
R,   9,   1.3200,     .1331,     .1584,    1.2000,    1.1000,,,     .3131
REAL,   9
E ,  186,  161
E ,  190,  165
R,  10,   1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,  10
E ,    8,  201
E ,  201,  108
E ,   93,  202
E ,  202,  193
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  233, ALL, 0.0,, 268,   5
D,  234, ALL, 0.0,, 269,   5
D,  235, ALL, 0.0,, 270,   5
D,  236, ALL, 0.0,, 271,   5
D,  237, ALL, 0.0,, 272,   5
D,  333, ALL, 0.0,, 368,   5
D,  334, ALL, 0.0,, 369,   5
D,  335, ALL, 0.0,, 370,   5
D,  336, ALL, 0.0,, 371,   5
D,  337, ALL, 0.0,, 372,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  201,FX,      -9.000
LWRITE
/COM *****LOAD CASE NO.  2*****
FDELE,  201,FX
F,  201,FX,      -9.000
F,  201,FZ,       1.000
```

```
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

EXAMPLE 4- Thin Symmetrical Clamp with Stanchion Attachments

The example problem shown in Figure 7 is a typical four bolt clamp with two stanchions attached. The process pipe has an outside diameter of 22 inches and is located at 24 inches from the left edge of the clamp as shown in Figure 7. The stock size of both clamp halves is 6 inches wide by 1 inch thick with an overall length of 48 inches. Four 1 inch diameter bolts are used to connect the two clamp halves.

Since the clamp and loads are symmetrical about the XZ plane, a symmetrical mesh will be used. A total of 152 quad plate elements will be generated to model each clamp body half. Quad plate elements are selected because of the 6 to 1 width to thickness ratio of the clamp cross-section (refer to section 5 for discussion on element selection).

A more refined mesh will be required for this problem because of the anticipated higher stress gradient caused by the stanchions. Both stanchions will be modeled using the flexible attachment option and will be refined along their lengths to 4 divisions (setting DIV= 4 on the attachment data).

In order to model the attachment locations and the cross-sectional dimensions (ex. width= 10" and depth= 4") must be specified for NuClamp. This is done by specifying control points at the four corner nodes of the attachment. If control points are not defined, then these points will take on the default node locations, which probably will not be of the required location. Only the corner nodes are required since to de defined, the remaining nodes along the attachment edge and interior will be evenly spaced by on the attachment by default. Because the attachments are located between IB2 and IB3, any control point within this region must be defined in the cylindrical coordinate system (refer to user's manual). Therefore, the X coordinate entered is actually the THETA coordinate.

The loads for this problem are applied to the ends of the attachment at the centroid of the attachment as shown in Figure 7. By default NuClamp assumes all clamp body nodes are applied at a point on the clamp's outer surface at the reference node. This location can be adjusted by specifying a DX, DY, and DZ relative offset from the reference node. For example, the DX, DY, and DZ for the load of the attachment on the top clamp half is: DX= 5.0, DY= 12.0, and DZ=2.0.

For simplicity, not all of the I, J-lines are shown in Figure 7.

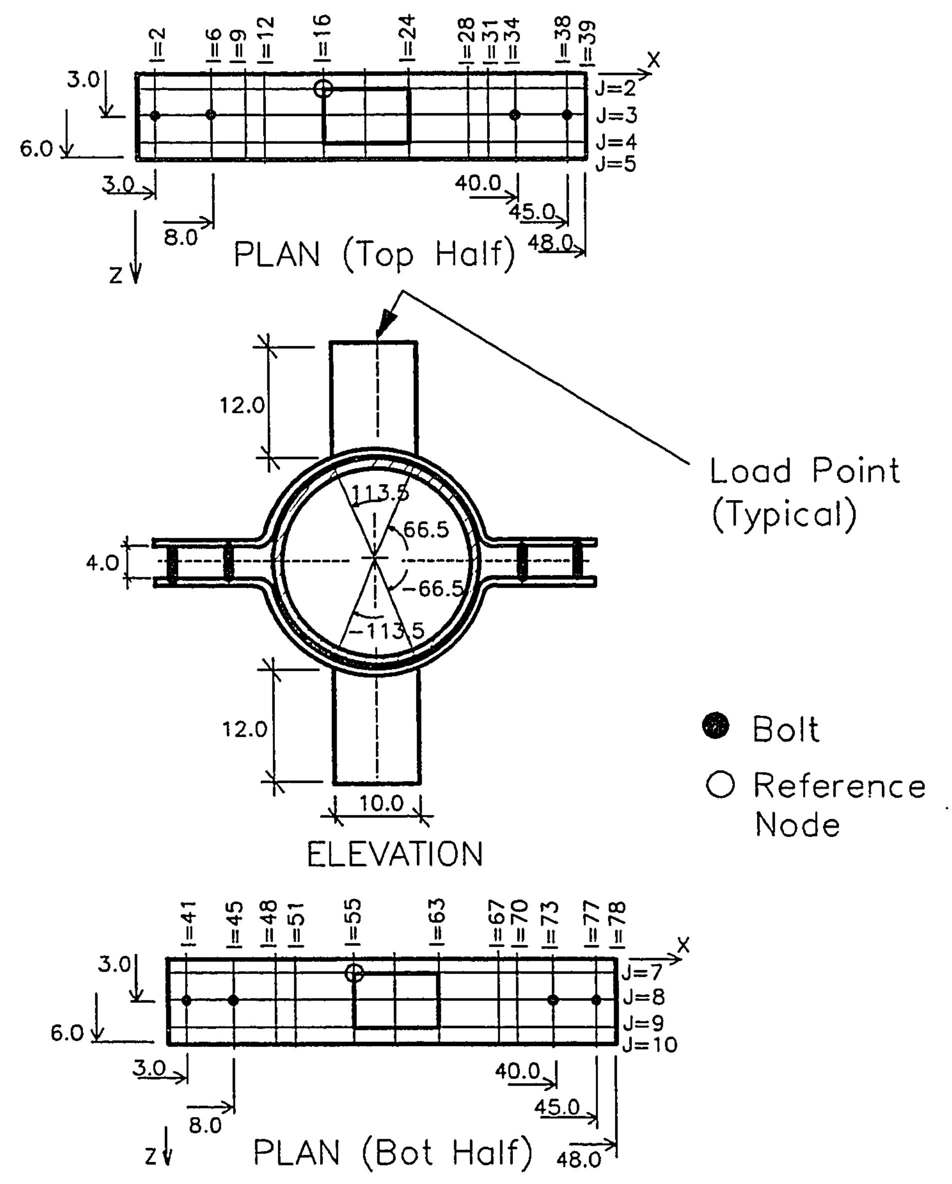

FIGURE 7 EXAMPLE 4 MODEL

The NuClamp input required is as follows:

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    4     8     1     2     0     0     2     0
TITLE:
Example 4
MATERIAL PROPERTIES:--------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
         29000.            .300
DIMENSIONS:-----------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
 48.000  6.000  1.000  4.000      0 39  5   9  12  28  31  2.000
 48.000  6.000  1.000  4.000      0 39  5  48  51  67  70  2.000
PIPE DATA:------------------------------------------------------------
    OD    MU X-CENTER
22.000  .300  24.000
BOLT DATA:------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z     DIA
      2       3      41       8  3.000   3.000   1.000
      6       3      45       8  8.000   3.000   1.000
     34       3      73       8 40.000   3.000   1.000
     38       3      77       8 45.000   3.000   1.000
CONTROL POINT DATA:---------------------------------------------------
    I    J        X         Z
   16    2  113.500     1.000
   16    4  113.500     5.000
   24    2   66.500     1.000
   24    4   66.500     5.000
   55    7 -113.500     1.000
   55    9 -113.500     5.000
   63    7  -66.500     1.000
   63    9  -66.500     5.000
ATTACHMENT DATA:------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   4   .500 12.000   90.0     0    4
I-START J-START   I-END   J-END
     16       2      24       2
     24       2      24       4
     24       4      16       4
     16       4      16       2
#SEG  THICK    HGT    ANG  TYPE  DIV
   4   .500 12.000  -90.0     0    4
I-START J-START   I-END   J-END
     55       7      63       7
     63       7      63       9
     63       9      55       9
```

```
    55        9       55        7
CLAMP LOAD DATA:------------------------------------------------------------
POI:     I     J      DX        DY        DZ
        16     2   5.000    12.000     2.000
LC#          FX           FY           FZ           MX           MY           MZ
  1       1.000         .000         .000         .000         .000         .000
POI:     I     J      DX        DY        DZ
        55     7   5.000   -12.000     2.000
LC#          FX           FY           FZ           MX           MY           MZ
  1       1.000         .000         .000         .000         .000         .000
```

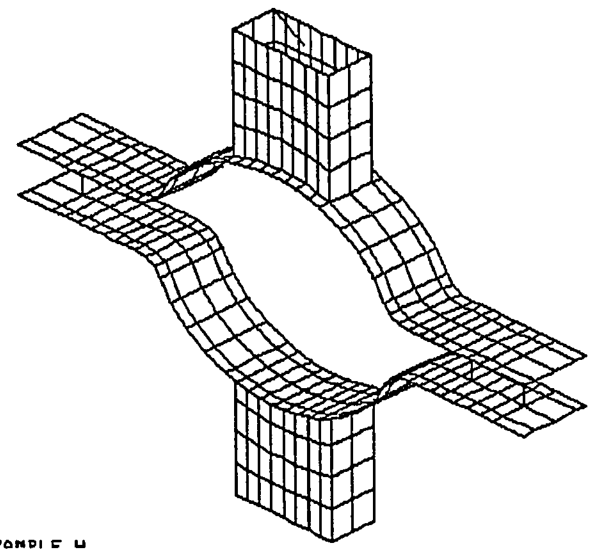

FIGURE 8 EXAMPLE 4 ANSYS PLOT

The ANSYS input generated by NuClamp is listed below. For a description on the various ANSYS input keywords and parameters, refer to the ANSYS User's Manual version 4.1.

```
/PREP7
/TITLE Example 4
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     29000.000
NUXY, 1,  .300
MU, 2,  .300
LOCAL, 11, 1,  24.000,   0.0,   0.0
LOCAL, 12, 1,  10.923,   5.000, 0.0
LOCAL, 13, 1,  37.077,   5.000, 0.0
LOCAL, 14, 1,  10.923,  -5.000, 0.0
LOCAL, 15, 1,  37.077,  -5.000, 0.0
CSYS, 0
N,    1,     .000,    2.500,     .000
N,    2,     .000,    2.500,    1.000
N,    3,     .000,    2.500,    3.000
N,    4,     .000,    2.500,    5.000
N,    5,     .000,    2.500,    6.000
```

N,	6,	3.000,	2.500,	.000
N,	7,	3.000,	2.500,	1.000
N,	8,	3.000,	2.500,	3.000
N,	9,	3.000,	2.500,	5.000
N,	10,	3.000,	2.500,	6.000
N,	11,	4.250,	2.500,	.000
N,	12,	4.250,	2.500,	1.000
N,	13,	4.250,	2.500,	3.000
N,	14,	4.250,	2.500,	5.000
N,	15,	4.250,	2.500,	6.000
N,	16,	5.500,	2.500,	.000
N,	17,	5.500,	2.500,	1.000
N,	18,	5.500,	2.500,	3.000
N,	19,	5.500,	2.500,	5.000
N,	20,	5.500,	2.500,	6.000
N,	21,	6.750,	2.500,	.000
N,	22,	6.750,	2.500,	1.000
N,	23,	6.750,	2.500,	3.000
N,	24,	6.750,	2.500,	5.000
N,	25,	6.750,	2.500,	6.000
N,	26,	8.000,	2.500,	.000
N,	27,	8.000,	2.500,	1.000
N,	28,	8.000,	2.500,	3.000
N,	29,	8.000,	2.500,	5.000
N,	30,	8.000,	2.500,	6.000
N,	31,	8.974,	2.500,	.000
N,	32,	8.974,	2.500,	1.000
N,	33,	8.974,	2.500,	3.000
N,	34,	8.974,	2.500,	5.000
N,	35,	8.974,	2.500,	6.000
N,	36,	9.949,	2.500,	.000
N,	37,	9.949,	2.500,	1.000
N,	38,	9.949,	2.500,	3.000
N,	39,	9.949,	2.500,	5.000
N,	40,	9.949,	2.500,	6.000
N,	41,	10.923,	2.500,	.000
N,	42,	10.923,	2.500,	1.000
N,	43,	10.923,	2.500,	3.000
N,	44,	10.923,	2.500,	5.000
N,	45,	10.923,	2.500,	6.000
N,	151,	37.077,	2.500,	.000
N,	152,	37.077,	2.500,	1.000
N,	153,	37.077,	2.500,	3.000
N,	154,	37.077,	2.500,	5.000
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N, 165, 39.026,  2.500, 6.000
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N, 185, 43.750,  2.500, 6.000
N, 186, 45.000,  2.500,  .000
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N, 192, 48.000,  2.500, 1.000
N, 193, 48.000,  2.500, 3.000
N, 194, 48.000,  2.500, 5.000
N, 195, 48.000,  2.500, 6.000
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N, 197,   .000, -2.500, 1.000
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N,  218,   6.750,   -2.500,   3.000
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N,  222,   8.000,   -2.500,   1.000
N,  223,   8.000,   -2.500,   3.000
N,  224,   8.000,   -2.500,   5.000
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N,  240,  10.923,   -2.500,   6.000
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N,  347,  37.077,   -2.500,   1.000
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N, 379, 43.750, -2.500, 5.000
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N, 381, 45.000, -2.500, .000
N, 382, 45.000, -2.500, 1.000
N, 383, 45.000, -2.500, 3.000
N, 384, 45.000, -2.500, 5.000
N, 385, 45.000, -2.500, 6.000
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N,  75,  11.500, 124.894,  6.000
N,  76,  11.500, 113.500,   .000
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N,  81,  11.500, 107.625,   .000
N,  82,  11.500, 107.625,  1.000
N,  83,  11.500, 107.625,  3.000
N,  84,  11.500, 107.625,  5.000
N,  85,  11.500, 107.625,  6.000
N,  86,  11.500, 101.750,   .000
N,  87,  11.500, 101.750,  1.000
N,  88,  11.500, 101.750,  3.000
N,  89,  11.500, 101.750,  5.000
N,  90,  11.500, 101.750,  6.000
N,  91,  11.500,  95.875,   .000
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N,  93,  11.500,  95.875,  3.000
N,  94,  11.500,  95.875,  5.000
N,  95,  11.500,  95.875,  6.000
N,  96,  11.500,  90.000,   .000
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N, 108,  11.500,  78.250,  3.000
N, 109,  11.500,  78.250,  5.000
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N,  113,  11.500,   72.375,   3.000
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N,  118,  11.500,   66.500,   3.000
N,  119,  11.500,   66.500,   5.000
N,  120,  11.500,   66.500,   6.000
N,  121,  11.500,   55.106,    .000
N,  122,  11.500,   55.106,   1.000
N,  123,  11.500,   55.106,   3.000
N,  124,  11.500,   55.106,   5.000
N,  125,  11.500,   55.106,   6.000
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N,  131,  11.500,   32.319,    .000
N,  132,  11.500,   32.319,   1.000
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N,  135,  11.500,   32.319,   6.000
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N,  137,  11.500,   20.925,   1.000
N,  138,  11.500,   20.925,   3.000
N,  139,  11.500,   20.925,   5.000
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N,  265,  11.500, -136.288,   6.000
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N, 271,  11.500, -113.500,    .000
N, 272,  11.500, -113.500,   1.000
N, 273,  11.500, -113.500,   3.000
N, 274,  11.500, -113.500,   5.000
N, 275,  11.500, -113.500,   6.000
N, 276,  11.500, -107.625,    .000
N, 277,  11.500, -107.625,   1.000
N, 278,  11.500, -107.625,   3.000
N, 279,  11.500, -107.625,   5.000
N, 280,  11.500, -107.625,   6.000
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N, 282,  11.500, -101.750,   1.000
N, 283,  11.500, -101.750,   3.000
N, 284,  11.500, -101.750,   5.000
N, 285,  11.500, -101.750,   6.000
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N, 287,  11.500,  -95.875,   1.000
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N, 290,  11.500,  -95.875,   6.000
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N, 294,  11.500,  -90.000,   5.000
N, 295,  11.500,  -90.000,   6.000
N, 296,  11.500,  -84.125,    .000
N, 297,  11.500,  -84.125,   1.000
N, 298,  11.500,  -84.125,   3.000
N, 299,  11.500,  -84.125,   5.000
N, 300,  11.500,  -84.125,   6.000
N, 301,  11.500,  -78.250,    .000
N, 302,  11.500,  -78.250,   1.000
N, 303,  11.500,  -78.250,   3.000
N, 304,  11.500,  -78.250,   5.000
N, 305,  11.500,  -78.250,   6.000
N, 306,  11.500,  -72.375,    .000
N, 307,  11.500,  -72.375,   1.000
N, 308,  11.500,  -72.375,   3.000
N, 309,  11.500,  -72.375,   5.000
N, 310,  11.500,  -72.375,   6.000
N, 311,  11.500,  -66.500,    .000
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N,  312,   11.500,  -66.500,    1.000
N,  313,   11.500,  -66.500,    3.000
N,  314,   11.500,  -66.500,    5.000
N,  315,   11.500,  -66.500,    6.000
N,  316,   11.500,  -55.106,     .000
N,  317,   11.500,  -55.106,    1.000
N,  318,   11.500,  -55.106,    3.000
N,  319,   11.500,  -55.106,    5.000
N,  320,   11.500,  -55.106,    6.000
N,  321,   11.500,  -43.712,     .000
N,  322,   11.500,  -43.712,    1.000
N,  323,   11.500,  -43.712,    3.000
N,  324,   11.500,  -43.712,    5.000
N,  325,   11.500,  -43.712,    6.000
N,  326,   11.500,  -32.319,     .000
N,  327,   11.500,  -32.319,    1.000
N,  328,   11.500,  -32.319,    3.000
N,  329,   11.500,  -32.319,    5.000
N,  330,   11.500,  -32.319,    6.000
N,  331,   11.500,  -20.925,     .000
N,  332,   11.500,  -20.925,    1.000
N,  333,   11.500,  -20.925,    3.000
N,  334,   11.500,  -20.925,    5.000
N,  335,   11.500,  -20.925,    6.000
CSYS, 12
N,   46,    2.500,  -66.975,     .000
N,   47,    2.500,  -66.975,    1.000
N,   48,    2.500,  -66.975,    3.000
N,   49,    2.500,  -66.975,    5.000
N,   50,    2.500,  -66.975,    6.000
N,   51,    2.500,  -43.950,     .000
N,   52,    2.500,  -43.950,    1.000
N,   53,    2.500,  -43.950,    3.000
N,   54,    2.500,  -43.950,    5.000
N,   55,    2.500,  -43.950,    6.000
CSYS, 13
N,  141,    2.500, -136.050,     .000
N,  142,    2.500, -136.050,    1.000
N,  143,    2.500, -136.050,    3.000
N,  144,    2.500, -136.050,    5.000
N,  145,    2.500, -136.050,    6.000
N,  146,    2.500, -113.025,     .000
N,  147,    2.500, -113.025,    1.000
N,  148,    2.500, -113.025,    3.000
N,  149,    2.500, -113.025,    5.000
N,  150,    2.500, -113.025,    6.000
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CSYS, 14
N, 241,    2.500,  66.975,     .000
N, 242,    2.500,  66.975,    1.000
N, 243,    2.500,  66.975,    3.000
N, 244,    2.500,  66.975,    5.000
N, 245,    2.500,  66.975,    6.000
N, 246,    2.500,  43.950,     .000
N, 247,    2.500,  43.950,    1.000
N, 248,    2.500,  43.950,    3.000
N, 249,    2.500,  43.950,    5.000
N, 250,    2.500,  43.950,    6.000
CSYS, 15
N, 336,    2.500, 136.050,     .000
N, 337,    2.500, 136.050,    1.000
N, 338,    2.500, 136.050,    3.000
N, 339,    2.500, 136.050,    5.000
N, 340,    2.500, 136.050,    6.000
N, 341,    2.500, 113.025,     .000
N, 342,    2.500, 113.025,    1.000
N, 343,    2.500, 113.025,    3.000
N, 344,    2.500, 113.025,    5.000
N, 345,    2.500, 113.025,    6.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2, 556,  56, 136,   5, -.1000, .0000, .0000
NGEN ,    2, 556,  57, 137,   5, -.1000, .0000, .0000
NGEN ,    2, 556,  58, 138,   5, -.1000, .0000, .0000
NGEN ,    2, 556,  59, 139,   5, -.1000, .0000, .0000
NGEN ,    2, 556,  60, 140,   5, -.1000, .0000, .0000
NGEN ,    2, 556, 251, 331,   5, -.1000, .0000, .0000
NGEN ,    2, 556, 252, 332,   5, -.1000, .0000, .0000
NGEN ,    2, 556, 253, 333,   5, -.1000, .0000, .0000
NGEN ,    2, 556, 254, 334,   5, -.1000, .0000, .0000
NGEN ,    2, 556, 255, 335,   5, -.1000, .0000, .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N, 391,   19.414,   13.705,   1.000
N, 392,   20.518,   14.015,   1.000
N, 393,   19.414,   16.864,   1.000
N, 394,   20.518,   17.071,   1.000
N, 395,   19.414,   20.023,   1.000
N, 396,   20.518,   20.126,   1.000
N, 397,   19.414,   23.182,   1.000
N, 398,   20.518,   23.181,   1.000
N, 399,   21.658,   14.239,   1.000
N, 400,   21.658,   17.220,   1.000
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N, 401, 21.658, 20.200, 1.000
N, 402, 21.657, 23.180, 1.000
N, 403, 22.823, 14.374, 1.000
N, 404, 22.822, 17.309, 1.000
N, 405, 22.822, 20.244, 1.000
N, 406, 22.822, 23.179, 1.000
N, 407, 24.000, 14.419, 1.000
N, 408, 24.000, 17.339, 1.000
N, 409, 23.999, 20.258, 1.000
N, 410, 23.999, 23.178, 1.000
N, 411, 25.177, 14.374, 1.000
N, 412, 25.177, 17.308, 1.000
N, 413, 25.176, 20.242, 1.000
N, 414, 25.176, 23.177, 1.000
N, 415, 26.342, 14.238, 1.000
N, 416, 26.342, 17.217, 1.000
N, 417, 26.341, 20.196, 1.000
N, 418, 26.341, 23.175, 1.000
N, 419, 27.482, 14.014, 1.000
N, 420, 27.482, 17.067, 1.000
N, 421, 27.482, 20.121, 1.000
N, 422, 27.482, 23.174, 1.000
N, 423, 28.586, 13.703, 1.000
N, 424, 28.586, 16.860, 1.000
N, 425, 28.586, 20.016, 1.000
N, 426, 28.586, 23.173, 1.000
N, 427, 28.586, 13.703, 3.000
N, 428, 28.586, 16.860, 3.000
N, 429, 28.586, 20.016, 3.000
N, 430, 28.586, 23.173, 3.000
N, 431, 28.586, 13.703, 5.000
N, 432, 28.586, 16.860, 5.000
N, 433, 28.586, 20.016, 5.000
N, 434, 28.586, 23.173, 5.000
N, 435, 27.482, 14.014, 5.000
N, 436, 27.482, 17.067, 5.000
N, 437, 27.482, 20.121, 5.000
N, 438, 27.482, 23.174, 5.000
N, 439, 26.342, 14.238, 5.000
N, 440, 26.342, 17.217, 5.000
N, 441, 26.341, 20.196, 5.000
N, 442, 26.341, 23.175, 5.000
N, 443, 25.177, 14.374, 5.000
N, 444, 25.177, 17.308, 5.000
N, 445, 25.176, 20.242, 5.000
N, 446, 25.176, 23.177, 5.000
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N, 447, 24.000, 14.419, 5.000
N, 448, 24.000, 17.339, 5.000
N, 449, 23.999, 20.258, 5.000
N, 450, 23.999, 23.178, 5.000
N, 451, 22.823, 14.374, 5.000
N, 452, 22.822, 17.309, 5.000
N, 453, 22.822, 20.244, 5.000
N, 454, 22.822, 23.179, 5.000
N, 455, 21.658, 14.239, 5.000
N, 456, 21.658, 17.220, 5.000
N, 457, 21.658, 20.200, 5.000
N, 458, 21.657, 23.180, 5.000
N, 459, 20.518, 14.015, 5.000
N, 460, 20.518, 17.071, 5.000
N, 461, 20.518, 20.126, 5.000
N, 462, 20.518, 23.181, 5.000
N, 463, 19.414, 13.705, 5.000
N, 464, 19.414, 16.864, 5.000
N, 465, 19.414, 20.023, 5.000
N, 466, 19.414, 23.182, 5.000
N, 467, 19.414, 13.705, 3.000
N, 468, 19.414, 16.864, 3.000
N, 469, 19.414, 20.023, 3.000
N, 470, 19.414, 23.182, 3.000
N, 471, 19.414, -13.705, 1.000
N, 472, 20.518, -14.016, 1.000
N, 473, 19.414, -16.864, 1.000
N, 474, 20.518, -17.072, 1.000
N, 475, 19.414, -20.023, 1.000
N, 476, 20.518, -20.128, 1.000
N, 477, 19.414, -23.182, 1.000
N, 478, 20.518, -23.183, 1.000
N, 479, 21.658, -14.240, 1.000
N, 480, 21.658, -17.222, 1.000
N, 481, 21.659, -20.203, 1.000
N, 482, 21.659, -23.185, 1.000
N, 483, 22.823, -14.376, 1.000
N, 484, 22.823, -17.313, 1.000
N, 485, 22.824, -20.249, 1.000
N, 486, 22.824, -23.186, 1.000
N, 487, 24.000, -14.422, 1.000
N, 488, 24.000, -17.343, 1.000
N, 489, 24.001, -20.265, 1.000
N, 490, 24.001, -23.187, 1.000
N, 491, 25.177, -14.377, 1.000
N, 492, 25.178, -17.314, 1.000
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N, 493, 25.178, -20.251, 1.000
N, 494, 25.178, -23.188, 1.000
N, 495, 26.342, -14.242, 1.000
N, 496, 26.342, -17.224, 1.000
N, 497, 26.342, -20.207, 1.000
N, 498, 26.343, -23.189, 1.000
N, 499, 27.482, -14.018, 1.000
N, 500, 27.482, -17.075, 1.000
N, 501, 27.482, -20.133, 1.000
N, 502, 27.482, -23.190, 1.000
N, 503, 28.586, -13.708, 1.000
N, 504, 28.586, -16.869, 1.000
N, 505, 28.586, -20.030, 1.000
N, 506, 28.586, -23.192, 1.000
N, 507, 28.586, -13.708, 3.000
N, 508, 28.586, -16.869, 3.000
N, 509, 28.586, -20.030, 3.000
N, 510, 28.586, -23.192, 3.000
N, 511, 28.586, -13.708, 5.000
N, 512, 28.586, -16.869, 5.000
N, 513, 28.586, -20.030, 5.000
N, 514, 28.586, -23.192, 5.000
N, 515, 27.482, -14.018, 5.000
N, 516, 27.482, -17.075, 5.000
N, 517, 27.482, -20.133, 5.000
N, 518, 27.482, -23.190, 5.000
N, 519, 26.342, -14.242, 5.000
N, 520, 26.342, -17.224, 5.000
N, 521, 26.342, -20.207, 5.000
N, 522, 26.343, -23.189, 5.000
N, 523, 25.177, -14.377, 5.000
N, 524, 25.178, -17.314, 5.000
N, 525, 25.178, -20.251, 5.000
N, 526, 25.178, -23.188, 5.000
N, 527, 24.000, -14.422, 5.000
N, 528, 24.000, -17.343, 5.000
N, 529, 24.001, -20.265, 5.000
N, 530, 24.001, -23.187, 5.000
N, 531, 22.823, -14.376, 5.000
N, 532, 22.823, -17.313, 5.000
N, 533, 22.824, -20.249, 5.000
N, 534, 22.824, -23.186, 5.000
N, 535, 21.658, -14.240, 5.000
N, 536, 21.658, -17.222, 5.000
N, 537, 21.659, -20.203, 5.000
N, 538, 21.659, -23.185, 5.000
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N, 539,  20.518, -14.016,   5.000
N, 540,  20.518, -17.072,   5.000
N, 541,  20.518, -20.128,   5.000
N, 542,  20.518, -23.183,   5.000
N, 543,  19.414, -13.705,   5.000
N, 544,  19.414, -16.864,   5.000
N, 545,  19.414, -20.023,   5.000
N, 546,  19.414, -23.182,   5.000
N, 547,  19.414, -13.705,   3.000
N, 548,  19.414, -16.864,   3.000
N, 549,  19.414, -20.023,   3.000
N, 550,  19.414, -23.182,   3.000
N, 551,   3.000,    .000,   3.000
N, 552,   8.000,    .000,   3.000
N, 553,  40.000,    .000,   3.000
N, 554,  45.000,    .000,   3.000
N, 555,  24.215,  23.005,   3.000
N, 556,  24.215, -23.005,   3.000
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,   1.000
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   38,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,   1.000
REAL,  2
E,  196,  197,  202,  201
EGEN,    4,    1,  153,  153,    1
EGEN,   38,    5,  153,  156,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 612,  56
EGEN,  17,   5, 305, 305,   1
EGEN,   5,   1, 305, 321,   1
E, 807, 251
EGEN,  17,   5, 390, 390,   1
EGEN,   5,   1, 390, 406,   1
/COM *****ATTACHMENT QUAD ELEMENTS*****
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TYPE, 2
MAT, 1
R, 4, .500
REAL, 4
E,  77,  82, 392, 391
E, 391, 392, 394, 393
E, 393, 394, 396, 395
E, 395, 396, 398, 397
E,  82,  87, 399, 392
E, 392, 399, 400, 394
E, 394, 400, 401, 396
E, 396, 401, 402, 398
E,  87,  92, 403, 399
E, 399, 403, 404, 400
E, 400, 404, 405, 401
E, 401, 405, 406, 402
E,  92,  97, 407, 403
E, 403, 407, 408, 404
E, 404, 408, 409, 405
E, 405, 409, 410, 406
E,  97, 102, 411, 407
E, 407, 411, 412, 408
E, 408, 412, 413, 409
E, 409, 413, 414, 410
E, 102, 107, 415, 411
E, 411, 415, 416, 412
E, 412, 416, 417, 413
E, 413, 417, 418, 414
E, 107, 112, 419, 415
E, 415, 419, 420, 416
E, 416, 420, 421, 417
E, 417, 421, 422, 418
E, 112, 117, 423, 419
E, 419, 423, 424, 420
E, 420, 424, 425, 421
E, 421, 425, 426, 422
E, 117, 118, 427, 423
E, 423, 427, 428, 424
E, 424, 428, 429, 425
E, 425, 429, 430, 426
E, 118, 119, 431, 427
E, 427, 431, 432, 428
E, 428, 432, 433, 429
E, 429, 433, 434, 430
E, 119, 114, 435, 431
E, 431, 435, 436, 432
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E, 432, 436, 437, 433
E, 433, 437, 438, 434
E, 114, 109, 439, 435
E, 435, 439, 440, 436
E, 436, 440, 441, 437
E, 437, 441, 442, 438
E, 109, 104, 443, 439
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E, 441, 445, 446, 442
E, 104,  99, 447, 443
E, 443, 447, 448, 444
E, 444, 448, 449, 445
E, 445, 449, 450, 446
E,  99,  94, 451, 447
E, 447, 451, 452, 448
E, 448, 452, 453, 449
E, 449, 453, 454, 450
E,  94,  89, 455, 451
E, 451, 455, 456, 452
E, 452, 456, 457, 453
E, 453, 457, 458, 454
E,  89,  84, 459, 455
E, 455, 459, 460, 456
E, 456, 460, 461, 457
E, 457, 461, 462, 458
E,  84,  79, 463, 459
E, 459, 463, 464, 460
E, 460, 464, 465, 461
E, 461, 465, 466, 462
E,  79,  78, 467, 463
E, 463, 467, 468, 464
E, 464, 468, 469, 465
E, 465, 469, 470, 466
E,  78,  77, 391, 467
E, 467, 391, 393, 468
E, 468, 393, 395, 469
E, 469, 395, 397, 470
E, 272, 277, 472, 471
E, 471, 472, 474, 473
E, 473, 474, 476, 475
E, 475, 476, 478, 477
E, 277, 282, 479, 472
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E, 474, 480, 481, 476
E, 476, 481, 482, 478
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E, 282, 287, 483, 479
E, 479, 483, 484, 480
E, 480, 484, 485, 481
E, 481, 485, 486, 482
E, 287, 292, 487, 483
E, 483, 487, 488, 484
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E, 485, 489, 490, 486
E, 292, 297, 491, 487
E, 487, 491, 492, 488
E, 488, 492, 493, 489
E, 489, 493, 494, 490
E, 297, 302, 495, 491
E, 491, 495, 496, 492
E, 492, 496, 497, 493
E, 493, 497, 498, 494
E, 302, 307, 499, 495
E, 495, 499, 500, 496
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E, 497, 501, 502, 498
E, 307, 312, 503, 499
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E, 500, 504, 505, 501
E, 501, 505, 506, 502
E, 312, 313, 507, 503
E, 503, 507, 508, 504
E, 504, 508, 509, 505
E, 505, 509, 510, 506
E, 313, 314, 511, 507
E, 507, 511, 512, 508
E, 508, 512, 513, 509
E, 509, 513, 514, 510
E, 314, 309, 515, 511
E, 511, 515, 516, 512
E, 512, 516, 517, 513
E, 513, 517, 518, 514
E, 309, 304, 519, 515
E, 515, 519, 520, 516
E, 516, 520, 521, 517
E, 517, 521, 522, 518
E, 304, 299, 523, 519
E, 519, 523, 524, 520
E, 520, 524, 525, 521
E, 521, 525, 526, 522
E, 299, 294, 527, 523
E, 523, 527, 528, 524
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E, 524, 528, 529, 525
E, 525, 529, 530, 526
E, 294, 289, 531, 527
E, 527, 531, 532, 528
E, 528, 532, 533, 529
E, 529, 533, 534, 530
E, 289, 284, 535, 531
E, 531, 535, 536, 532
E, 532, 536, 537, 533
E, 533, 537, 538, 534
E, 284, 279, 539, 535
E, 535, 539, 540, 536
E, 536, 540, 541, 537
E, 537, 541, 542, 538
E, 279, 274, 543, 539
E, 539, 543, 544, 540
E, 540, 544, 545, 541
E, 541, 545, 546, 542
E, 274, 273, 547, 543
E, 543, 547, 548, 544
E, 544, 548, 549, 545
E, 545, 549, 550, 546
E, 273, 272, 471, 547
E, 547, 471, 473, 548
E, 548, 473, 475, 549
E, 549, 475, 477, 550
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   5,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,   5
E ,  397,  398
E ,  398,  402
E ,  402,  406
E ,  406,  410
E ,  410,  414
E ,  414,  418
E ,  418,  422
E ,  422,  426
E ,  426,  430
E ,  430,  434
E ,  434,  438
E ,  438,  442
E ,  442,  446
E ,  446,  450
E ,  450,  454
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E ,  454,  458
E ,  458,  462
E ,  462,  466
E ,  466,  470
E ,  470,  397
E ,  477,  478
E ,  478,  482
E ,  482,  486
E ,  486,  490
E ,  490,  494
E ,  494,  498
E ,  498,  502
E ,  502,  506
E ,  506,  510
E ,  510,  514
E ,  514,  518
E ,  518,  522
E ,  522,  526
E ,  526,  530
E ,  530,  534
E ,  534,  538
E ,  538,  542
E ,  542,  546
E ,  546,  550
E ,  550,  477
R,   6,     .7854,     .0491,     .0491,     1.0000,     1.0000,,,      .0982
REAL,   6
E ,    8,  551
E ,  551,  203
E ,   28,  552
E ,  552,  223
E ,  168,  553
E ,  553,  363
E ,  188,  554
E ,  554,  383
R,   7,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,   7
E ,  397,  555
E ,  477,  556
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  612, ALL, 0.0,, 692,   5
D,  613, ALL, 0.0,, 693,   5
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D,  614, ALL, 0.0,, 694,   5
D,  615, ALL, 0.0,, 695,   5
D,  616, ALL, 0.0,, 696,   5
D,  807, ALL, 0.0,, 887,   5
D,  808, ALL, 0.0,, 888,   5
D,  809, ALL, 0.0,, 889,   5
D,  810, ALL, 0.0,, 890,   5
D,  811, ALL, 0.0,, 891,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  555,FX,       1.000
F,  556,FX,       1.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

EXAMPLE 5- Thin Clamp with Unsymmetrical Attachments

The example problem shown in Figure 9 is geometrically identical to example 1 except that this problem has four different attachments. As with example 1 this is a typical two bolt clamp with the process pipe having an outside diameter of 12 inches with its centered located at 10-5/8 inches from the left edge of the clamp as shown in Figure 9. The stock size of both clamp halves is 3 inches wide by 3/4 inch thick with an overall length of 21.5 inches. Two bolts are used to connect the two clamp halves. The left bolt has a diameter of 1-1/2 inches, and the right bolt is 1 inch in diameter.

A total of 92 quad plate elements will be generated to model each clamp body half. Quad plate elements are selected because of the 6 to 1 width to thickness ratio of the clamp cross-section (refer to section 5 for discussion on element selection).

The four attachments to this clamp are all pipe sections. The diameters of each are shown in Figure 9. The circular cross-section of the attachments are modeled assuming a diamond shaped footprint.

All attachments will be modeled using the flexible attachment option. Each will be refined along their lengths (setting DIV= #divisions on the attachment data).

In order to model the attachment locations, the cross-sectional dimensions must be specified for NuClamp. This is done by specifying control points at the four corner nodes of the attachment. If control points are not defined, then these points will take on the default node locations, which probably will not be of the required location. Only the corner nodes are required since to de defined, the remaining nodes along the attachment edge and interior will be evenly spaced on the attachment by default. Because the attachments are located between IB2 and IB3, any control point within this region must be defined in the cylindrical coordinate system (refer to user's manual). Therefore, the X coordinate entered is actually the THETA coordinate.

The clamp body loads for this problem are applied at the locations specified on the POI cards. By default NuClamp assumes all clamp body nodes to be applied at a point on the clamp's outer surface at the reference node. This location can be adjusted by specifying a DX, DY, and DZ relative offset from the reference node.

For simplicity, not all of the I, J-lines are shown in Figure 9.

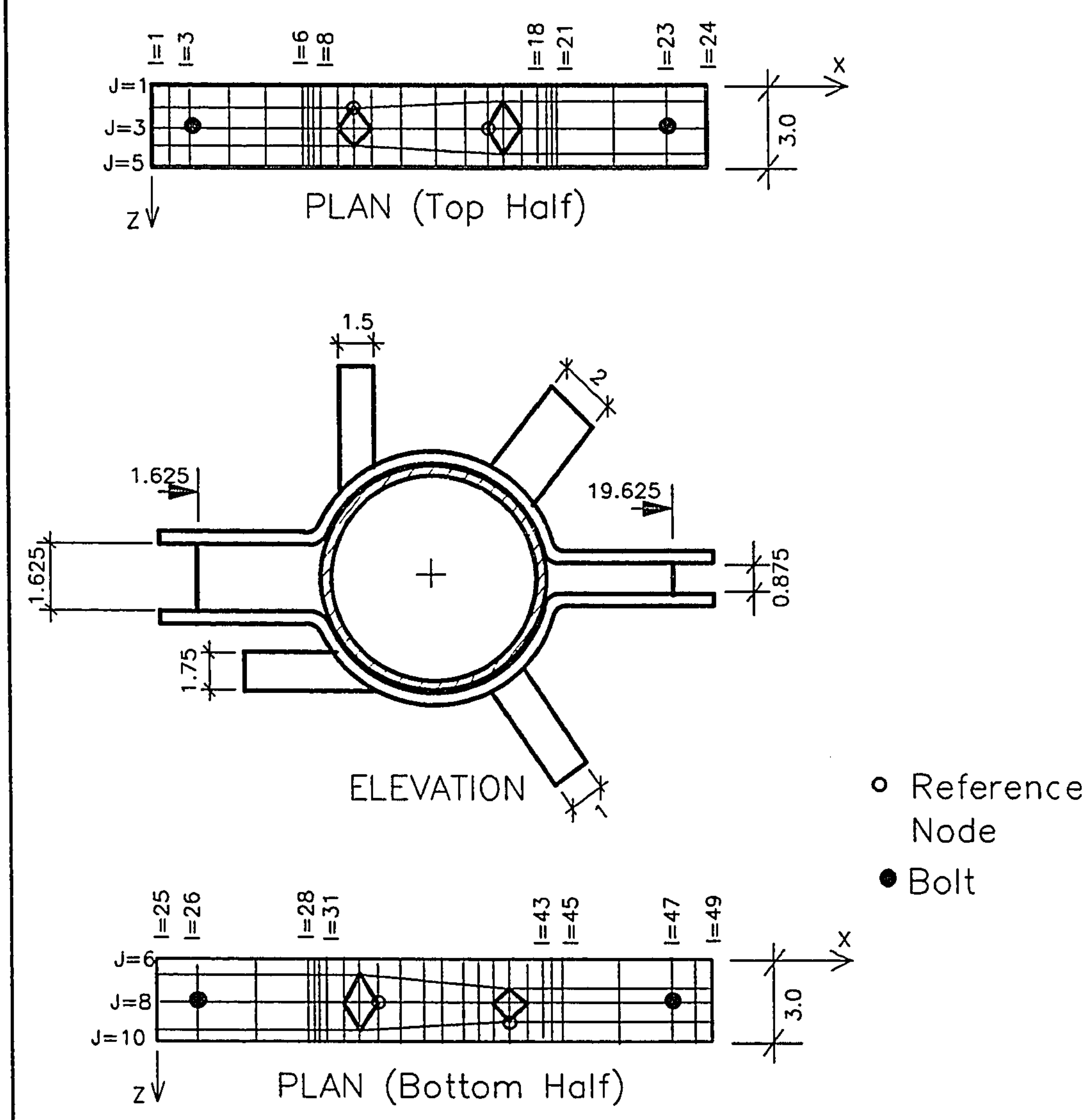

FIGURE 9 EXAMPLE 5 MODEL

The NuClamp input required is as follows:

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2    16     1     2     0     0     4     0
TITLE:
TEST3
MATERIAL PROPERTIES:----------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
       29000.              .330
DIMENSIONS:-------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4     RAD
 21.500  3.000   .750  1.625      0 24  5   6   8  18  21  1.000
 21.500  3.000   .750   .875      0 25  5  28  31  43  45  1.000
PIPE DATA:--------------------------------------------------------------
    OD     MU X-CENTER
12.000   .000   10.625
BOLT DATA:--------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
      3       3      26       8  1.625   1.500   1.500
     23       3      47       8 19.625   1.500   1.000
CONTROL POINT DATA:-----------------------------------------------------
    I    J        X         Z
    9    3  145.000     1.500
   10    2  135.000      .750
   10    4  135.000     2.250
   11    3  126.000     1.500
   15    3   54.000     1.500
   16    2   45.000      .500
   16    4   45.000     2.500
   17    3   31.000     1.500
   32    8 -145.000     1.500
   33    7 -135.000      .625
   33    9 -135.000     2.375
   34    8 -125.000     1.500
   40    8  -52.000     1.500
   41    7  -45.000     1.000
   41    9  -45.000     2.000
   42    8  -40.000     1.500
ATTACHMENT DATA:--------------------------------------------------------
#SEG THICK    HGT    ANG  TYPE  DIV
  4   .100  3.500   90.0     0    2
I-START J-START   I-END   J-END
     10       2      11       3
     11       3      10       4
     10       4       9       3
      9       3      10       2
#SEG THICK    HGT    ANG  TYPE  DIV
  4   .200  3.000   45.0     1    1
I-START J-START   I-END   J-END
     15       3      16       4
     16       4      17       3
     17       3      16       2
     16       2      15       3
#SEG THICK    HGT    ANG  TYPE  DIV
  4   .300  3.000 -179.0     0    4
I-START J-START   I-END   J-END
     34       8      33       7
     34       8      33       9
     32       8      33       7
     32       8      33       9
#SEG THICK    HGT    ANG  TYPE  DIV
  4   .400  4.000  -73.0     1    3
I-START J-START   I-END   J-END
     41       9      40       8
     41       7      40       8
     41       9      42       8
     41       7      42       8
CLAMP LOAD DATA:--------------------------------------------------------
```

```
POI:    I    J     DX      DY      DZ
       10    2   .000    .000    .750
LC#     FX        FY      FZ      MX      MY      MZ
 1      1.        2.      3.      4.      5.      6.
POI:    I    J     DX      DY      DZ
       34    8   .000   -.875    .000
LC#     FX        FY      FZ      MX      MY      MZ
 1      7.        8.      9.     10.     11.     12.
```

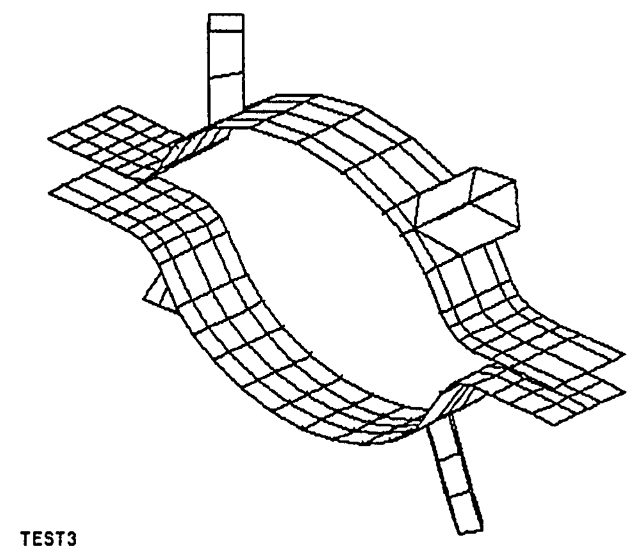

FIGURE 10 EXAMPLE 5 ANSYS PLOT

The ANSYS input generated by NuClamp is listed below. For a description on the various ANSYS input keywords and parameters, refer to the ANSYS User's Manual version 4.1.

```
/PREP7
/TITLE TEST3
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     29000.000
NUXY, 1,  .330
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.490,   2.313, 0.0
LOCAL, 13, 1,  17.870,   1.938, 0.0
```

```
LOCAL, 14, 1,   3.490,  -2.313, 0.0
LOCAL, 15, 1,  17.870,  -1.938, 0.0
CSYS, 0
N,    1,      .000,    1.063,     .000
N,    2,      .000,    1.063,     .750
N,    3,      .000,    1.063,    1.500
N,    4,      .000,    1.063,    2.250
N,    5,      .000,    1.063,    3.000
N,    6,      .813,    1.063,     .000
N,    7,      .813,    1.063,     .750
N,    8,      .813,    1.063,    1.500
N,    9,      .813,    1.063,    2.250
N,   10,      .813,    1.063,    3.000
N,   11,     1.625,    1.063,     .000
N,   12,     1.625,    1.063,     .750
N,   13,     1.625,    1.063,    1.500
N,   14,     1.625,    1.063,    2.250
N,   15,     1.625,    1.063,    3.000
N,   16,     2.247,    1.063,     .000
N,   17,     2.247,    1.063,     .750
N,   18,     2.247,    1.063,    1.500
N,   19,     2.247,    1.063,    2.250
N,   20,     2.247,    1.063,    3.000
N,   21,     2.869,    1.063,     .000
N,   22,     2.869,    1.063,     .750
N,   23,     2.869,    1.063,    1.500
N,   24,     2.869,    1.063,    2.250
N,   25,     2.869,    1.063,    3.000
N,   26,     3.490,    1.063,     .000
N,   27,     3.490,    1.063,     .750
N,   28,     3.490,    1.063,    1.500
N,   29,     3.490,    1.063,    2.250
N,   30,     3.490,    1.063,    3.000
N,  101,    17.870,     .688,     .000
N,  102,    17.870,     .688,     .500
N,  103,    17.870,     .688,    1.500
N,  104,    17.870,     .688,    2.500
N,  105,    17.870,     .688,    3.000
N,  106,    18.748,     .688,     .000
N,  107,    18.748,     .688,     .500
N,  108,    18.748,     .688,    1.500
N,  109,    18.748,     .688,    2.500
N,  110,    18.748,     .688,    3.000
N,  111,    19.625,     .688,     .000
N,  112,    19.625,     .688,     .500
N,  113,    19.625,     .688,    1.500
```

```
N,  114,  19.625,    .688,  2.500
N,  115,  19.625,    .688,  3.000
N,  116,  21.500,    .688,   .000
N,  117,  21.500,    .688,   .500
N,  118,  21.500,    .688,  1.500
N,  119,  21.500,    .688,  2.500
N,  120,  21.500,    .688,  3.000
N,  121,    .000,  -1.063,   .000
N,  122,    .000,  -1.063,   .625
N,  123,    .000,  -1.063,  1.500
N,  124,    .000,  -1.063,  2.375
N,  125,    .000,  -1.063,  3.000
N,  126,   1.625,  -1.063,   .000
N,  127,   1.625,  -1.063,   .625
N,  128,   1.625,  -1.063,  1.500
N,  129,   1.625,  -1.063,  2.375
N,  130,   1.625,  -1.063,  3.000
N,  131,   2.558,  -1.063,   .000
N,  132,   2.558,  -1.063,   .625
N,  133,   2.558,  -1.063,  1.500
N,  134,   2.558,  -1.063,  2.375
N,  135,   2.558,  -1.063,  3.000
N,  136,   3.490,  -1.063,   .000
N,  137,   3.490,  -1.063,   .625
N,  138,   3.490,  -1.063,  1.500
N,  139,   3.490,  -1.063,  2.375
N,  140,   3.490,  -1.063,  3.000
N,  221,  17.870,   -.688,   .000
N,  222,  17.870,   -.688,  1.000
N,  223,  17.870,   -.688,  1.500
N,  224,  17.870,   -.688,  2.000
N,  225,  17.870,   -.688,  3.000
N,  226,  18.748,   -.688,   .000
N,  227,  18.748,   -.688,  1.000
N,  228,  18.748,   -.688,  1.500
N,  229,  18.748,   -.688,  2.000
N,  230,  18.748,   -.688,  3.000
N,  231,  19.625,   -.688,   .000
N,  232,  19.625,   -.688,  1.000
N,  233,  19.625,   -.688,  1.500
N,  234,  19.625,   -.688,  2.000
N,  235,  19.625,   -.688,  3.000
N,  236,  20.563,   -.688,   .000
N,  237,  20.563,   -.688,  1.000
N,  238,  20.563,   -.688,  1.500
N,  239,  20.563,   -.688,  2.000
```

```
N, 240,  20.563,    -.688,    3.000
N, 241,  21.500,    -.688,     .000
N, 242,  21.500,    -.688,    1.000
N, 243,  21.500,    -.688,    1.500
N, 244,  21.500,    -.688,    2.000
N, 245,  21.500,    -.688,    3.000
CSYS, 11
N,  36,   6.250,  162.041,     .000
N,  37,   6.250,  162.041,     .750
N,  38,   6.250,  162.041,    1.500
N,  39,   6.250,  162.041,    2.250
N,  40,   6.250,  162.041,    3.000
N,  41,   6.250,  145.000,     .000
N,  42,   6.250,  145.000,     .750
N,  43,   6.250,  145.000,    1.500
N,  44,   6.250,  145.000,    2.250
N,  45,   6.250,  145.000,    3.000
N,  46,   6.250,  135.000,     .000
N,  47,   6.250,  135.000,     .750
N,  48,   6.250,  135.000,    1.500
N,  49,   6.250,  135.000,    2.250
N,  50,   6.250,  135.000,    3.000
N,  51,   6.250,  126.000,     .000
N,  52,   6.250,  126.000,     .708
N,  53,   6.250,  126.000,    1.500
N,  54,   6.250,  126.000,    2.292
N,  55,   6.250,  126.000,    3.000
N,  56,   6.250,  108.000,     .000
N,  57,   6.250,  108.000,     .667
N,  58,   6.250,  108.000,    1.500
N,  59,   6.250,  108.000,    2.333
N,  60,   6.250,  108.000,    3.000
N,  61,   6.250,   90.000,     .000
N,  62,   6.250,   90.000,     .625
N,  63,   6.250,   90.000,    1.500
N,  64,   6.250,   90.000,    2.375
N,  65,   6.250,   90.000,    3.000
N,  66,   6.250,   72.000,     .000
N,  67,   6.250,   72.000,     .583
N,  68,   6.250,   72.000,    1.500
N,  69,   6.250,   72.000,    2.417
N,  70,   6.250,   72.000,    3.000
N,  71,   6.250,   54.000,     .000
N,  72,   6.250,   54.000,     .542
N,  73,   6.250,   54.000,    1.500
N,  74,   6.250,   54.000,    2.458
```

N,	75,	6.250,	54.000,	3.000
N,	76,	6.250,	45.000,	.000
N,	77,	6.250,	45.000,	.500
N,	78,	6.250,	45.000,	1.500
N,	79,	6.250,	45.000,	2.500
N,	80,	6.250,	45.000,	3.000
N,	81,	6.250,	31.000,	.000
N,	82,	6.250,	31.000,	.500
N,	83,	6.250,	31.000,	1.500
N,	84,	6.250,	31.000,	2.500
N,	85,	6.250,	31.000,	3.000
N,	86,	6.250,	14.971,	.000
N,	87,	6.250,	14.971,	.500
N,	88,	6.250,	14.971,	1.500
N,	89,	6.250,	14.971,	2.500
N,	90,	6.250,	14.971,	3.000
N,	151,	6.250,	-162.041,	.000
N,	152,	6.250,	-162.041,	.625
N,	153,	6.250,	-162.041,	1.500
N,	154,	6.250,	-162.041,	2.375
N,	155,	6.250,	-162.041,	3.000
N,	156,	6.250,	-145.000,	.000
N,	157,	6.250,	-145.000,	.625
N,	158,	6.250,	-145.000,	1.500
N,	159,	6.250,	-145.000,	2.375
N,	160,	6.250,	-145.000,	3.000
N,	161,	6.250,	-135.000,	.000
N,	162,	6.250,	-135.000,	.625
N,	163,	6.250,	-135.000,	1.500
N,	164,	6.250,	-135.000,	2.375
N,	165,	6.250,	-135.000,	3.000
N,	166,	6.250,	-125.000,	.000
N,	167,	6.250,	-125.000,	.672
N,	168,	6.250,	-125.000,	1.500
N,	169,	6.250,	-125.000,	2.328
N,	170,	6.250,	-125.000,	3.000
N,	171,	6.250,	-112.833,	.000
N,	172,	6.250,	-112.833,	.719
N,	173,	6.250,	-112.833,	1.500
N,	174,	6.250,	-112.833,	2.281
N,	175,	6.250,	-112.833,	3.000
N,	176,	6.250,	-100.667,	.000
N,	177,	6.250,	-100.667,	.766
N,	178,	6.250,	-100.667,	1.500
N,	179,	6.250,	-100.667,	2.234
N,	180,	6.250,	-100.667,	3.000

```
N,  181,    6.250,  -88.500,     .000
N,  182,    6.250,  -88.500,     .813
N,  183,    6.250,  -88.500,    1.500
N,  184,    6.250,  -88.500,    2.188
N,  185,    6.250,  -88.500,    3.000
N,  186,    6.250,  -76.333,     .000
N,  187,    6.250,  -76.333,     .859
N,  188,    6.250,  -76.333,    1.500
N,  189,    6.250,  -76.333,    2.141
N,  190,    6.250,  -76.333,    3.000
N,  191,    6.250,  -64.167,     .000
N,  192,    6.250,  -64.167,     .906
N,  193,    6.250,  -64.167,    1.500
N,  194,    6.250,  -64.167,    2.094
N,  195,    6.250,  -64.167,    3.000
N,  196,    6.250,  -52.000,     .000
N,  197,    6.250,  -52.000,     .953
N,  198,    6.250,  -52.000,    1.500
N,  199,    6.250,  -52.000,    2.047
N,  200,    6.250,  -52.000,    3.000
N,  201,    6.250,  -45.000,     .000
N,  202,    6.250,  -45.000,    1.000
N,  203,    6.250,  -45.000,    1.500
N,  204,    6.250,  -45.000,    2.000
N,  205,    6.250,  -45.000,    3.000
N,  206,    6.250,  -40.000,     .000
N,  207,    6.250,  -40.000,    1.000
N,  208,    6.250,  -40.000,    1.500
N,  209,    6.250,  -40.000,    2.000
N,  210,    6.250,  -40.000,    3.000
N,  211,    6.250,  -14.971,     .000
N,  212,    6.250,  -14.971,    1.000
N,  213,    6.250,  -14.971,    1.500
N,  214,    6.250,  -14.971,    2.000
N,  215,    6.250,  -14.971,    3.000
 CSYS, 12
 N,   31,    1.250,  -53.979,     .000
 N,   32,    1.250,  -53.979,     .750
 N,   33,    1.250,  -53.979,    1.500
 N,   34,    1.250,  -53.979,    2.250
 N,   35,    1.250,  -53.979,    3.000
 CSYS, 13
 N,   91,    1.250, -140.019,     .000
 N,   92,    1.250, -140.019,     .500
 N,   93,    1.250, -140.019,    1.500
 N,   94,    1.250, -140.019,    2.500
```

```
N,   95,    1.250, -140.019,    3.000
N,   96,    1.250, -115.010,     .000
N,   97,    1.250, -115.010,     .500
N,   98,    1.250, -115.010,    1.500
N,   99,    1.250, -115.010,    2.500
N,  100,    1.250, -115.010,    3.000
CSYS, 14
N,  141,    1.250,   65.986,     .000
N,  142,    1.250,   65.986,     .625
N,  143,    1.250,   65.986,    1.500
N,  144,    1.250,   65.986,    2.375
N,  145,    1.250,   65.986,    3.000
N,  146,    1.250,   41.973,     .000
N,  147,    1.250,   41.973,     .625
N,  148,    1.250,   41.973,    1.500
N,  149,    1.250,   41.973,    2.375
N,  150,    1.250,   41.973,    3.000
CSYS, 15
N,  216,    1.250,  127.514,     .000
N,  217,    1.250,  127.514,    1.000
N,  218,    1.250,  127.514,    1.500
N,  219,    1.250,  127.514,    2.000
N,  220,    1.250,  127.514,    3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  289,   36,   86,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,   37,   87,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,   38,   88,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,   39,   89,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,   40,   90,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,  151,  211,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,  152,  212,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,  153,  213,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,  154,  214,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,  155,  215,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  246,    6.206,    6.339,     .750
N,  247,    6.951,    6.657,    1.500
N,  248,    6.206,    8.258,     .750
N,  249,    6.951,    8.257,    1.500
N,  250,    6.206,    6.339,    2.250
N,  251,    6.206,    8.258,    2.250
N,  252,    5.506,    5.922,    1.500
N,  253,    5.506,    8.259,    1.500
N,  254,   16.599,    7.357,    1.500
```

```
N,  255,  17.290,   6.665,   2.500
N,  256,  18.359,   5.596,   1.500
N,  257,  17.290,   6.665,    .500
N,  258,   6.188,  -5.135,   1.500
N,  259,   5.559,  -4.431,    .625
N,  260,   5.335,  -5.149,   1.500
N,  261,   4.911,  -4.442,    .625
N,  262,   4.482,  -5.164,   1.500
N,  263,   4.264,  -4.453,    .625
N,  264,   3.630,  -5.179,   1.500
N,  265,   3.617,  -4.465,    .625
N,  266,   5.559,  -4.431,   2.375
N,  267,   4.911,  -4.442,   2.375
N,  268,   4.264,  -4.453,   2.375
N,  269,   3.617,  -4.465,   2.375
N,  270,   5.030,  -3.593,   1.500
N,  271,   4.554,  -3.601,   1.500
N,  272,   4.078,  -3.610,   1.500
N,  273,   3.603,  -3.618,   1.500
N,  274,  15.462,  -5.784,   2.000
N,  275,  14.859,  -6.189,   1.500
N,  276,  15.879,  -7.149,   2.000
N,  277,  15.246,  -7.453,   1.500
N,  278,  16.296,  -8.514,   2.000
N,  279,  15.632,  -8.717,   1.500
N,  280,  15.462,  -5.784,   1.000
N,  281,  15.879,  -7.149,   1.000
N,  282,  16.296,  -8.514,   1.000
N,  283,  15.857,  -5.470,   1.500
N,  284,  16.301,  -6.924,   1.500
N,  285,  16.746,  -8.377,   1.500
N,  286,   1.625,    .000,   1.500
N,  287,  19.625,    .000,   1.500
N,  288,   6.029,   4.596,   1.500
N,  289,   6.897,  -6.199,   1.500
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .500
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   23,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
```

```
R, 2,    .500
REAL,  2
E,  121,  122,  127,  126
EGEN,    4,    1,   93,   93,    1
EGEN,   24,    5,   93,   96,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 325,  36
EGEN,  11,    5, 189, 189,   1
EGEN,   5,    1, 189, 199,   1
E, 440, 151
EGEN,  13,    5, 244, 244,   1
EGEN,   5,    1, 244, 256,   1
/COM *****ATTACHMENT QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R,  4,  .100
REAL,  4
E,   47,   53,  247,  246
E,  246,  247,  249,  248
E,   53,   49,  250,  247
E,  247,  250,  251,  249
E,   49,   43,  252,  250
E,  250,  252,  253,  251
E,   43,   47,  246,  252
E,  252,  246,  248,  253
R,  5,  .200
REAL,  5
E,   73,   79,  255,  254
E,   79,   83,  256,  255
E,   83,   77,  257,  256
E,   77,   73,  254,  257
R,  6,  .300
REAL,  6
E,  168,  162,  259,  258
E,  258,  259,  261,  260
E,  260,  261,  263,  262
E,  262,  263,  265,  264
E,  168,  164,  266,  258
E,  258,  266,  267,  260
E,  260,  267,  268,  262
E,  262,  268,  269,  264
E,  158,  162,  259,  270
```

```
E, 270, 259, 261, 271
E, 271, 261, 263, 272
E, 272, 263, 265, 273
E, 158, 164, 266, 270
E, 270, 266, 267, 271
E, 271, 267, 268, 272
E, 272, 268, 269, 273
R, 7, .400
REAL, 7
E, 204, 198, 275, 274
E, 274, 275, 277, 276
E, 276, 277, 279, 278
E, 202, 198, 275, 280
E, 280, 275, 277, 281
E, 281, 277, 279, 282
E, 204, 208, 283, 274
E, 274, 283, 284, 276
E, 276, 284, 285, 278
E, 202, 208, 283, 280
E, 280, 283, 284, 281
E, 281, 284, 285, 282
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  8, 100.0000, 999.0000, 999.0000,   1.0000,   1.0000,,, 999.0000
REAL,  8
E , 248, 249
E , 249, 251
E , 251, 253
E , 253, 248
E , 264, 265
E , 264, 269
E , 273, 265
E , 273, 269
R,  9,   1.7671,    .2485,    .2485,   1.5000,   1.5000,,,    .4970
REAL,  9
E ,  13, 286
E , 286, 128
R, 10,    .7854,    .0491,    .0491,   1.0000,   1.0000,,,    .0982
REAL, 10
E , 113, 287
E , 287, 233
R, 11, 100.0000, 999.0000, 999.0000,   1.0000,   1.0000,,, 999.0000
REAL, 11
E , 248, 288
E , 264, 289
```

```
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  325, ALL, 0.0,, 375,   5
D,  326, ALL, 0.0,, 376,   5
D,  327, ALL, 0.0,, 377,   5
D,  328, ALL, 0.0,, 378,   5
D,  329, ALL, 0.0,, 379,   5
D,  440, ALL, 0.0,, 500,   5
D,  441, ALL, 0.0,, 501,   5
D,  442, ALL, 0.0,, 502,   5
D,  443, ALL, 0.0,, 503,   5
D,  444, ALL, 0.0,, 504,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  288,FX,        1.000
F,  288,FY,        2.000
F,  288,FZ,        3.000
F,  288,MX,        4.000
F,  288,MY,        5.000
F,  288,MZ,        6.000
F,  289,FX,        7.000
F,  289,FY,        8.000
F,  289,FZ,        9.000
F,  289,MX,       10.000
F,  289,MY,       11.000
F,  289,MZ,       12.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

SECTION 6 ELEMENT SELECTION DISCUSSION

Unfortunately there isn't any well defined method to determine whether quad plate or brick elements should be used to model the clamp body. The choice of elements requires engineering judgement that comes from experience. However, the following are some factors that play a role in the final determination:

WIDTH to THICKNESS RATIO

In the theoretical formulation of the quad plate and brick elements, certain assumptions are made. The theory for quad plate elements assume 'thin plate behavior' which is valid when the width to thickness ratio exceeds 10 to 1. The theory for brick elements assumes 'thick plate behavior' which is valid when the width to thickness ratio is less than 4 to 1. Unfortunately most pipe clamps are in the middle range between 4 and 10.

WARPING

Warping is defined as the condition when the cross-section of the material does not remain plane, as shown in Figure 11. Notice that any 4 points on the cross-section can not form a single flat plane. Warping typically occurs when the cross-section is in a state of bi-axial bending. If significant warping is present, then brick elements must be used.

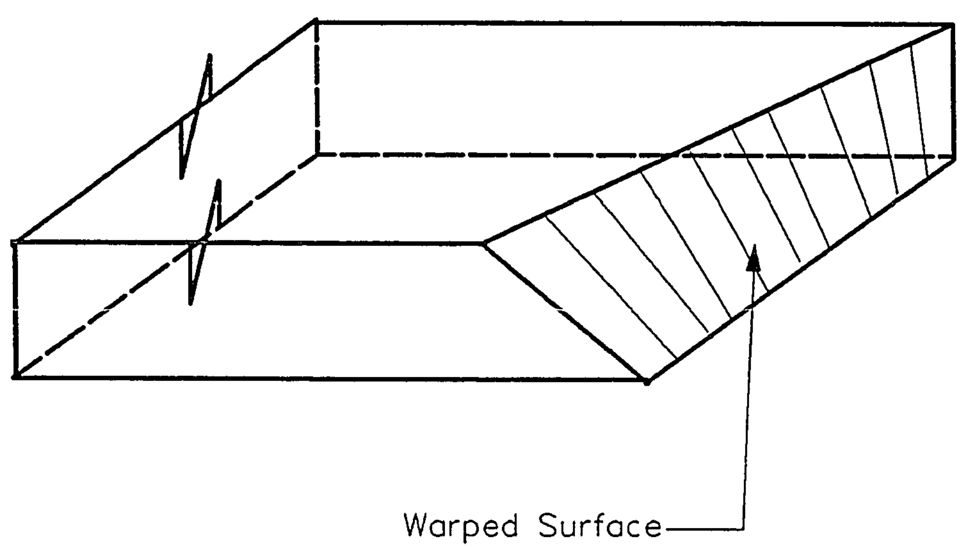

FIGURE 11 WARPING OF A CROSS-SECTION

SECTION 7 MESH SIZE DISCUSSION

As with element selection, there isn't any well defined method for determining the mesh size. However, the following are some factors to consider when determining the mesh size:

STRESS GRADIENT

Stress gradient is a measure of the change in stress over a unit length. For example, the stress gradient of a truss member under an axial load is zero since the stress is the same at all points along the member. The stress gradient would be non-zero in the case of a cantilever beam since the stress varies along the length of the beam.

The stress gradient is important because in order to capture rapid changes in stress, more elements are required. If overly coarse meshes are used, the stresses tend to be averaged over a longer length. This tends to obscure the higher more localized stresses.

In pipe clamps, high stress gradients are usually located near attachments, bolts, and near the pipe bend, in other words, those areas which have a rapid or sudden change in geometry or applied loads.

In general, a finer mesh is required in those areas which have a high stress gradient.

ASPECT RATIO

The aspect ratio (length to width ratio) of an element can influence the accuracy of the results. The ideal aspect ratio for both the quad plate and brick element is 1. As the elements deviate from the ideal, the accuracy of the stress computation diminishes. Typically, sufficient accuracy is acceptable up to an aspect ratio of 4 or 5.

APPENDIX C Validation Manual

This appendix contains the Validation manual that describes the 18 problems that were used to validate NuClamp.

The manual format is typical of that used in the nuclear industry and is written to be self-contained from the thesis.

NuClamp

Validation Manual

Version 1.0

DISCLAIMER OF WARRANTY

Every reasonable effort has been made to provide a comprehensive and flexible computer program. However, the computer program itself and associated documentation are supplied without representation of warranty, expressed or implied, as to their content, accuracy, or freedom from defects or errors.

RECORD OF REVISION	
REVISION	DESCRIPTION
0	Manual Released

LIST OF EFFECTIVE PAGES							
PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV
i	0	2-1	0	4-1	0	4-21	0
ii	0	2-2	0	4-2	0		
iii	0	2-3	0	4-3	0		
iv	0	2-4	0	4-4	0		
v	0			4-5	0		
vi	0			4-6	0	5-1 thru 7	0
				4-7	0	5-8 thru 16	0
				4-8	0	5-17 thru 27	0
				4-9	0	5-28 thru 35	0
		3-1	0	4-10	0	5-36 thru 46	0
		3-2	0	4-11	0	5-47 thru 63	0
1-1	0	3-3	0	4-12	0	5-64 thru 70	0
		3-4	0	4-13	0	5-71 thru 79	0
		3-5	0	4-14	0	5-80 thru 90	0
				4-15	0	5-91 thru 98	0
				4-16	0	5-99 thru 109	0
				4-17	0	5-110 thru 126	0
				4-18	0	5-127 thru 135	0
				4-19	0	5-136 thru 144	0
				4-20	0	5-145 thru 153	0
						5-154 thru 162	0
						5-163 thru 169	0
						5-170 thru 177	0

PREFACE

NuClamp is a pre-processor computer program that can generate the necessary finite element model and input to analyze most standard or non-standard pipe clamps.

NuClamp was developed to provide the user with a tool to perform the finite element analysis of a pipe clamp with minimal user input and training. This was accomplished by constructing an interface between the user and ANSYS (version 4.1) using a model building method that is commonly used in the nuclear power industry. Depending on the clamp's complexity, NuClamp requires approximately 20 lines of input data. NuClamp's input data consists of the clamp's overall dimensions, pipe size, bolt sizes and locations, applied loads, and mesh gradation.

Once the ANSYS file has been generated by NuClamp, the user can modify the ANSYS data file before the actual finite element analysis is performed.

Table of Contents

1 INTRODUCTION

All features of NuClamp have been validated on a CYBER 960 series computer according to NuSoft's Quality Assurance Procedures (revision 1.0).

A total of 18 problems have been validated. Because of complex behavior of pipe clamps, closed form solutions cannot be used to validated the program. This program is therefore validated by reviewing the ANSYS input file created. The ANSYS file (Appendix 5) will be reviewed to insure that sound finite element modeling principles are used to model the clamp.

2 VALIDATION OF PROGRAM FEATURES

The validation summary table in this section lists the feature being validated and the corresponding validation problem number.

VALIDATED FEATURE	PROBLEM NUMBER
Interactive Input	All
Batch Input	All
Title	All
Clamp Dimensions (XMAX, ZMAX, THK)	All
Youngs Modulus	1, 2, 7, 8
Poison Ratio	1, 2, 7, 8
Bend Radius (IB1, IB2, IB3, IB4)	All
Friction Coefficient (Mu)	1, 4, 7, 12
Clamp Body Nodes (X, Y, Z coordinates)	1, 7, 8, 9, 13, 14
Clamp Body Elements	
Quad elements (PLDIV= 0)	1 thru 6, 13, 14, 17
Brick elements (PLDIV> 0)	7 thru 12, 15, 16, 18
Loads	
Bolt load point	1, 2, 6, 7, 8, 12 thru 16
Clamp load point	3, 4, 5, 6, 9, 10, 11, 12, 17, 18
Load offset (DX, DY, DZ)	3, 4, 5, 6, 9, 10, 11, 12, 17, 18
Load beam connectivity and properties	3, 4, 5, 6, 9, 10, 11, 12, 17, 18
Load directions and magnitude	All
Multiple load points	3, 5, 6, 9, 11, 12
Multiple load cases	4, 10, 13, 14, 15, 16
User Beams	
Between different coordinate systems	4, 10, 13, 14, 15, 16
Between same coordinate system	13, 14, 15, 16
Beam properties	4, 10, 13, 14, 15, 16
Beam orientation	4, 10, 13, 14, 15, 16
Beam connectivity	4, 10, 13, 14, 15, 16
Attachment (General)	
Segment Definition	3, 5, 6, 9, 11, 12, 17, 18

Across different coordinate systems	5, 6, 11, 12
Load Bearing Attachment	
Beam connectivity	3, 5, 6, 9, 11, 12
Beam property	3, 5, 6, 9, 11, 12
Quad plate connectivity	3, 5, 6, 9, 11, 12
Quad plate properties	3, 5, 6, 9, 11, 12
Node coordinates	3, 5, 6, 9, 11, 12
#Div	3, 5, 6, 9, 11, 12
Non-Load Bearing Attachment	
Quad Plate connectivity	3, 6, 9, 12
Quad plate properties	3, 6, 9, 12
#Div	3, 6, 9, 12
Node coordinates	3, 6, 9, 12
Rigid Attachment	
Beam connectivity	6, 12 thru 18
Beam property	6, 12 thru 18
Control Points	
Flat section (csys= 0)	3, 6, 9, 12, 17, 18
Pipe section (csys= 11)	3, 6, 9, 12
Edge boundary	13, 14, 15, 16
User Restraints	
Node number	6, 12
Pin code	6, 12
Bolts	
Properties	All
Connectivity	All
Center load node	All
Gap Elements	
Spring constant	All

Connectivity	All
Element type	All
Node location	All

3 VALIDATION PROBLEM DESCRIPTION

PROBLEM NUMBER	DESCRIPTION
1	2-bolt clamp symmetrical clamp and mesh quad plate elements for clamp body bolt load youngs modulus, poison ratio, and no friction one load case
2	2-bolt clamp symmetrical clamp unsymmetrical mesh quad plate elements for clamp body youngs modulus and poison ratio one load case
3	2-bolt clamp symmetrical clamp and mesh quad plate elements symmetrical clamp and mesh youngs modulus, and poison ratio multiple attachments at various orientations load bearing and non-load bearing attachments one load case clamp load load offset multiple load points different bolt diameters control points
4	2-bolt clamp quad plate elements symmetrical clamp and mesh youngs modulus, poison ratio, and friction attachment segment along diagonal user defined beams

multiple load cases
clamp load
load offset

5 2-bolt clamp
quad plate elements
symmetrical clamp and mesh
load bearing attachments
multiple attachments
different bend radii
different clamp thickness
multiple load points
load offset
one load case

6 4-bolt clamp
quad plate elements
symmetrical clamp and mesh
different bend radii
multiple flexible attachments
load bearing and non-load bearing attachments
control points
user restraints
mixed clamp and bolt load points
load offset
different bolt diameters
one load case

7 2-bolt clamp
symmetrical clamp and mesh
brick plate elements for clamp body
bolt load
youngs modulus, poison ratio, and no friction
one load case

8 4-bolt clamp
symmetrical clamp

unsymmetrical mesh
brick plate elements for clamp body
youngs modulus and poison ratio
one load case

9 4-bolt clamp
symmetrical clamp and mesh
brick plate elements
symmetrical clamp and mesh
youngs modulus, and poison ratio
multiple attachments at various orientations
load bearing and non-load bearing attachments
user defined beams
clamp load
load offset
multiple load points
one load case
different bolt diameters
control points

10 4-bolt clamp
brick plate elements
symmetrical clamp and mesh
youngs modulus, poison ratio, and friction
attachment segment along diagonal
user defined beams
multiple load cases
clamp load
load offset

11 4-bolt clamp
brick plate elements
symmetrical clamp and mesh
load bearing and non-load bearing attachments
multiple attachments
different bend radii
different clamp thickness

	multiple load points load offset one load case
12	4-bolt clamp brick plate elements symmetrical clamp and mesh different bend radii multiple flexible attachments load bearing and non-load bearing attachments control points user restraints mixed clamp and bolt load points load offset one load case different bolt diameters
13	3-bolt clamp quad plate elements unsymmetrical clamp and mesh different bend radii rigid attachment control points on boundaries different bolt diameters user defined beams 2 load cases bolt load
14	3-bolt clamp quad plate elements unsymmetrical clamp and mesh different bend radii rigid attachment control points on boundaries different bolt diameters user defined beams 2 load cases bolt load

15	3-bolt clamp brick plate elements unsymmetrical clamp and mesh different bend radii rigid attachment control points on boundaries different bolt diameters user defined beams 2 load cases bolt load
16	3-bolt clamp brick plate elements unsymmetrical clamp and mesh different bend radii rigid attachment control points on boundaries different bolt diameters user defined beams 2 load cases bolt load
17	2-bolt clamp quad plate elements symmetrical clamp and mesh control points rigid attachments clamp load point one load case
18	2-bolt clamp brick plate elements symmetrical clamp and mesh control points rigid attachments clamp load point one load case

4 VALIDATION PROBLEM INPUT

Validation Problem No. 1

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   2     0     1     0     1     0     0     0
TITLE:
TEST1
MATERIAL PROPERTIES:------------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        30000.            .300
DIMENSIONS:---------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
 21.500  3.000   .750  1.625      0 20  5   5   7  14  16  1.000
 21.500  3.000   .750   .875      0 20  5  25  27  34  36  1.000
PIPE DATA:----------------------------------------------------------------
    OD     MU X-CENTER
12.000  .000   10.625
BOLT DATA:----------------------------------------------------------------
I-START J-START   I-END   J-END      X      Z      DIA
      2       3      22       8  1.625  1.500    1.500
     19       3      39       8 19.625  1.500    1.500
BOLT LOAD DATA:-----------------------------------------------------------
LOAD BOLT#
  1
LC#      FX       FY       FZ
  1     -9.       0.       0.
```

Validation Problem No. 2

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   2     0     1     0     1     0     0     0
TITLE:
TEST2
MATERIAL PROPERTIES:------------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        29000.            .200
DIMENSIONS:---------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
 21.500  3.000   .750  1.625      0 27  7   6   8  18  21  1.000
 21.500  3.000   .750   .875      0 17  5  33  34  39  41  1.000
PIPE DATA:----------------------------------------------------------------
    OD     MU X-CENTER
12.000  .000   10.625
BOLT DATA:----------------------------------------------------------------
I-START J-START   I-END   J-END      X      Z      DIA
      2       4      30      10  1.625  1.500    1.500
     26       4      43      10 19.625  1.500    1.500
```

```
BOLT LOAD DATA:-----------------------------------------------------------
LOAD BOLT#
  1
LC#     FX      FY      FZ
  1    -9.      0.      0.
```

Validation Problem No. 3

```
#BOLT #CTRL  #LC #C-PT #B-PT #BEAM  #ATT #REST
    2    16    1     2     0     0     4     0
TITLE:
TEST3
MATERIAL PROPERTIES:-----------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        29000.            .330
DIMENSIONS:--------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
 21.500 3.000   .750  1.625      0 24  5   6   8  18  21  1.000
 21.500 3.000   .750   .875      0 25  5  28  31  43  45  1.000
PIPE DATA:---------------------------------------------------------------
   OD     MU X-CENTER
12.000  .000   10.625
BOLT DATA:---------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
      3       3      26       8  1.625   1.500   1.500
     23       3      47       8 19.625   1.500   1.000
CONTROL POINT DATA:------------------------------------------------------
    I    J        X        Z
    9    3  145.000    1.500
   10    2  135.000     .750
   10    4  135.000    2.250
   11    3  126.000    1.500
   15    3   54.000    1.500
   16    2   45.000     .500
   16    4   45.000    2.500
   17    3   31.000    1.500
   32    8 -145.000    1.500
   33    7 -135.000     .625
   33    9 -135.000    2.375
   34    8 -125.000    1.500
   40    8  -52.000    1.500
   41    7  -45.000    1.000
   41    9  -45.000    2.000
   42    8  -40.000    1.500
 ATTACHMENT DATA:--------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   4   .100  3.500   90.0     0    2
```

```
 I-START J-START   I-END   J-END
     10       2      11       3
     11       3      10       4
     10       4       9       3
      9       3      10       2
#SEG  THICK    HGT    ANG  TYPE  DIV
  4   .200  3.000   45.0    1    1
 I-START J-START   I-END   J-END
     15       3      16       4
     16       4      17       3
     17       3      16       2
     16       2      15       3
#SEG  THICK    HGT    ANG  TYPE  DIV
  4   .300  3.000 -179.0    0    4
 I-START J-START   I-END   J-END
     34       8      33       7
     34       8      33       9
     32       8      33       7
     32       8      33       9
#SEG  THICK    HGT    ANG  TYPE  DIV
  4   .400  4.000  -73.0    1  . 3
 I-START J-START   I-END   J-END
     41       9      40       8
     41       7      40       8
     41       9      42       8
     41       7      42       8
 CLAMP LOAD DATA:-----------------------------------------------------
 POI:     I     J     DX     DY     DZ
         10     2   .000   .000   .750
 LC#     FX        FY      FZ      MX      MY      MZ
  1      1.        2.      3.      4.      5.      6.
 POI:     I     J     DX     DY     DZ
         34     8   .000  -.875   .000
 LC#     FX        FY      FZ      MX      MY      MZ
  1      7.        8.      9.     10.     11.     12.
```

Validation Problem No. 4

```
 #BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
     2     0     2     1     0     8     1     0
 TITLE:
 TEST4
 MATERIAL PROPERTIES:-------------------------------------------------
 YOUNG'S MODULUS  POISSON'S RATIO
        29999.           .340
 DIMENSIONS:----------------------------------------------------------
    XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
```

```
21.500  3.000   .750  1.625      0 20  5   5   7  14  16  1.000
21.500  3.000   .750   .875      0 20  5  25  27  34  36  1.000
PIPE DATA:------------------------------------------------------------
    OD    MU X-CENTER
12.000  .150   10.625
BOLT DATA:------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
     2       3      22       8  1.625   1.500   1.500
    19       3      39       8 19.625   1.500   1.500
ATTACHMENT DATA:------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   1   .000   .000     .1     0    0
I-START J-START   I-END   J-END
    11       3      13       5
BEAM DATA:------------------------------------------------------------
 I-START J-START   I-END   J-END       W       H
       3       1       9       1   1.100   1.200
       3       5       9       5   1.100   1.200
      23       6      29       6   2.100   2.200
      23      10      29      10   2.300   2.400
      18       1      13       1   2.500   2.400
      18       5      13       5   2.900   2.800
      38       6      33       6   1.100   1.200
      38      10      33      10   1.100   1.200
CLAMP LOAD DATA:------------------------------------------------------
POI:     I     J     DX      DY      DZ
        11     3  5.100   6.100   7.100
LC#         FX          FY          FZ          MX          MY          MZ
  1      1.111       2.222       3.333       4.444       5.555       6.666
  2     -1.111      -2.222      -3.333      -4.444      -5.555      -6.666
```

Validation Problem No. 5

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   2     0     1     2     0     0     2     0
TITLE:
TEST5
MATERIAL PROPERTIES:--------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        30000.            .300
DIMENSIONS:-----------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I  #J  IB1  IB2  IB3  IB4    RAD
 21.500  3.000   .500   .875      0 20  5   5   7  14  16   .500
 21.500  3.000   .750  1.625      0 20  5  25  27  34  36  1.500
PIPE DATA:------------------------------------------------------------
    OD    MU X-CENTER
12.000  .000   10.625
```

```
BOLT DATA:------------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
    2       3       22       8  1.625   1.500   1.500
   19       3       39       8 19.625   1.500   1.500
ATTACHMENT DATA:------------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
  4   .100  3.000   90.0    0    1
I-START J-START   I-END   J-END
    8       2      10       4
   10       4      13       4
   13       4      13       1
   13       1      11       1
#SEG  THICK    HGT    ANG  TYPE  DIV
  1   .200  8.000  -90.0    0    3
I-START J-START   I-END   J-END
   21       8      40       8
CLAMP LOAD DATA:------------------------------------------------------------
POI:    I    J     DX     DY     DZ
        8    2   .000   .000   .000
LC#        FX         FY         FZ         MX         MY         MZ
  1     1.000      2.000      3.000      4.000      5.000      6.000
POI:    I    J     DX     DY     DZ
       21    8   .500   .600   .700
LC#        FX         FY         FZ         MX         MY         MZ
  1     7.000      8.000      9.000     10.000     11.000     12.000
```

Validation Problem No. 6

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   4    24     1     1     1     0     5     8
TITLE:
TEST6
MATERIAL PROPERTIES:--------------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
       30000.            .300
DIMENSIONS:-----------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
 20.000  4.000   .750  1.500      0 31  7   8  11  23  26  1.000
 20.000  4.000  1.000  1.000      0 31  7  39  42  54  57  1.500
PIPE DATA:------------------------------------------------------------------
    OD     MU X-CENTER
 8.000   .000   11.000
BOLT DATA:------------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
     3       3      34      10  2.000   1.250    .750
     3       5      34      12  2.000   2.750    .750
     6       4      37      11  4.500   2.000   1.000
```

```
    29       4      60      11 18.000  2.000   1.000
CONTROL POINT DATA:-----------------------------------------------------
    I    J        X        Z
    5    3    3.500    1.250
    5    5    3.500    2.750
   13    3  135.000    1.250
   13    5  135.000    2.750
   16    3  104.000    1.000
   16    5  104.000    3.000
   18    3   76.000    1.000
   18    5   76.000    3.000
   21    3   45.000    1.250
   21    5   45.000    2.750
   30    3   18.750    1.250
   30    5   18.750    2.750
   37   10    3.500    1.250
   37   12    3.500    2.750
   44   10 -135.000    1.250
   44   12 -135.000    2.750
   47   10 -104.000    1.000
   47   12 -104.000    3.000
   49   10  -76.000    1.000
   49   12  -76.000    3.000
   52   10  -45.000    1.250
   52   12  -45.000    2.750
   61   10   18.750    1.250
   61   12   18.750    2.750
 ATTACHMENT DATA:-------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  2.000  115.0     1    1
 I-START J-START   I-END   J-END
      13       3       5       3
      13       5       5       5
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  2.000   60.0     1    1
 I-START J-START   I-END   J-END
      21       3      30       3
      21       5      30       5
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  2.000 -115.0     1    1
 I-START J-START   I-END   J-END
      44      10      36      10
      44      12      36      12
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  2.000  -60.0     1    2
 I-START J-START   I-END   J-END
```

```
      52       10       61       10
      52       12       61       12
 #SEG  THICK    HGT     ANG  TYPE  DIV
   4   .000   .000   90.0     0    0
  I-START J-START   I-END   J-END
      16        3      18       3
      18        3      18       5
      18        5      16       5
      16        5      16       3
 RESTRAINT DATA:-----------------------------------------------------
     I    J   PIN-CODE
    13    1     00100
    13    7     00100
    21    1     00100
    21    7     00100
    44    8     00100
    44   14     00100
    52    8     00100
    52   14     00100
 CLAMP LOAD DATA:----------------------------------------------------
 POI:    I    J     DX      DY      DZ
        16    3  1.000    .000   1.000
 LC#          FX          FY          FZ          MX          MY          MZ
   1       1.000       2.000       3.000       4.000       5.000       6.000
 BOLT LOAD DATA:-----------------------------------------------------
 LOAD BOLT#
   1
 LC#          FX          FY          FZ
   1       7.000       8.000       9.000
```

Validation Problem No. 7

```
 #BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
     2     0     1     0     1     0     0     0
 TITLE:
 TEST7
 MATERIAL PROPERTIES:------------------------------------------------
 YOUNG'S MODULUS  POISSON'S RATIO
         30000.             .300
 DIMENSIONS:---------------------------------------------------------
    XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4     RAD
  21.500  3.000   .750  1.625      1 20  5   5   7  14  16   1.000
  21.500  3.000   .750   .875      1 20  5  25  27  34  36   1.000
 PIPE DATA:----------------------------------------------------------
    OD     MU X-CENTER
 12.000  .000   10.625
 BOLT DATA:----------------------------------------------------------
```

```
I-START J-START   I-END   J-END      X       Z      DIA
    2       3      22       8  1.625   1.500   1.500
   19       3      39       8 19.625   1.500   1.500
BOLT LOAD DATA:--------------------------------------------------------
LOAD BOLT#
 1
LC#     FX      FY      FZ
 1     -9.      0.      0.
```

Validation Problem No. 8

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2     0     1     0     1     0     0     0
TITLE:
TEST8
MATERIAL PROPERTIES:-------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        29000.            .200
DIMENSIONS:----------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4   RAD
 21.500  3.000   .750  1.625      2 27  7   6   8  18  21  1.000
 21.500  3.000   .750   .875      1 17  5  33  34  39  41  1.000
PIPE DATA:-----------------------------------------------------------
   OD    MU X-CENTER
12.000  .000   10.625
BOLT DATA:-----------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
    2       4      30      10  1.625   1.500   1.500
   26       4      43      10 19.625   1.500   1.500
BOLT LOAD DATA:------------------------------------------------------
LOAD BOLT#
 1
LC#     FX      FY      FZ
 1     -9.      0.      0.
```

Validation Problem No. 9

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2    16     1     2     0     0     4     0
TITLE:
TEST9
MATERIAL PROPERTIES:-------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        29000.            .330
DIMENSIONS:----------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4   RAD
 21.500  3.000   .750  1.625      1 24  5   6   8  18  21  1.000
 21.500  3.000   .750   .875      2 25  5  28  31  43  45  1.000
```

```
PIPE DATA:-------------------------------------------------------------
   OD    MU X-CENTER
12.000  .000   10.625
BOLT DATA:-------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
     3       3      26       8  1.625   1.500   1.500
    23       3      47       8 19.625   1.500   1.000
CONTROL POINT DATA:----------------------------------------------------
    I    J        X         Z
    9    3  145.000     1.500
   10    2  135.000      .750
   10    4  135.000     2.250
   11    3  126.000     1.500
   15    3   54.000     1.500
   16    2   45.000      .500
   16    4   45.000     2.500
   17    3   31.000     1.500
   32    8 -145.000     1.500
   33    7 -135.000      .625
   33    9 -135.000     2.375
   34    8 -125.000     1.500
   40    8  -52.000     1.500
   41    7  -45.000     1.000
   41    9  -45.000     2.000
   42    8  -40.000     1.500
ATTACHMENT DATA:-------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
  4    .100  3.500   90.0     0    2
 I-START J-START   I-END   J-END
      10       2      11       3
      11       3      10       4
      10       4       9       3
       9       3      10       2
#SEG  THICK    HGT    ANG  TYPE  DIV
  4    .200  3.000   45.0     1    1
 I-START J-START   I-END   J-END
      15       3      16       4
      16       4      17       3
      17       3      16       2
      16       2      15       3
#SEG  THICK    HGT    ANG  TYPE  DIV
  4    .300  3.000 -179.0     0    4
 I-START J-START   I-END   J-END
      34       8      33       7
      34       8      33       9
      32       8      33       7
```

```
     32        8       33        9
#SEG  THICK    HGT    ANG  TYPE  DIV
  4   .400  4.000  -73.0    1    3
 I-START J-START   I-END   J-END
     41        9       40        8
     41        7       40        8
     41        9       42        8
     41        7       42        8
 CLAMP LOAD DATA:-----------------------------------------------------
 POI:    I    J     DX      DY      DZ
        10    2   .000    .000    .750
 LC#       FX        FY        FZ        MX        MY        MZ
   1       1.        2.        3.        4.        5.        6.
 POI:    I    J     DX      DY      DZ
        34    8   .000   -.875    .000
 LC#       FX        FY        FZ        MX        MY        MZ
   1       7.        8.        9.       10.       11.       12.
```

Validation Problem No. 10

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2     0     2     1     0     8     1     0
TITLE:
TEST10
MATERIAL PROPERTIES:------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
       29999.            .340
DIMENSIONS:---------------------------------------------------------
    XMAX    ZMAX   THICK   SPACE #LAYER #I  #J  IB1  IB2  IB3  IB4     RAD
  21.500   3.000    .750   1.625      1 20   5    5    7   14   16   1.000
  21.500   3.000    .750    .875      3 20   5   25   27   34   36   1.000
PIPE DATA:----------------------------------------------------------
     OD     MU X-CENTER
 12.000   .150   10.625
BOLT DATA:----------------------------------------------------------
I-START J-START   I-END   J-END       X        Z      DIA
      2       3      22       8   1.625    1.500    1.500
     19       3      39       8  19.625    1.500    1.500
ATTACHMENT DATA:----------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
  1   .000   .000     .1    0    0
I-START J-START   I-END   J-END
     11       3      13       5
BEAM DATA:----------------------------------------------------------
 I-START J-START   I-END   J-END       W        H
       3       1       9       1   1.100    1.200
       3       5       9       5   1.100    1.200
```

```
      23      6      29      6   2.100   2.200
      23     10      29     10   2.300   2.400
      18      1      13      1   2.500   2.400
      18      5      13      5   2.900   2.800
      38      6      33      6   1.100   1.200
      38     10      33     10   1.100   1.200
CLAMP LOAD DATA:-----------------------------------------------------
POI:    I    J    DX     DY     DZ
       11    3  5.100  6.100  7.100
LC#       FX        FY        FZ        MX        MY        MZ
  1     1.111     2.222     3.333     4.444     5.555     6.666
  2    -1.111    -2.222    -3.333    -4.444    -5.555    -6.666
```

Validation Problem No. 11

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2     0     1     2     0     0     2     0
TITLE:
TEST11
MATERIAL PROPERTIES:---------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
       30000.           .300
DIMENSIONS:------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I  #J  IB1  IB2  IB3  IB4    RAD
 21.500  3.000   .500   .875      1 20   5    5    7   14   16   .500
 21.500  3.000   .750  1.625      0 20   5   25   27   34   36  1.500
PIPE DATA:-------------------------------------------------------
     OD     MU X-CENTER
 12.000   .000   10.625
BOLT DATA:-------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
      2       3      22       8  1.625   1.500    1.500
     19       3      39       8 19.625   1.500    1.500
ATTACHMENT DATA:-------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   4   .100  3.000   90.0     0    1
I-START J-START   I-END   J-END
      8       2      10       4
     10       4      13       4
     13       4      13       1
     13       1      11       1
#SEG  THICK    HGT    ANG  TYPE  DIV
   1   .200  8.000  -90.0     0    3
I-START J-START   I-END   J-END
     21       8      40       8
CLAMP LOAD DATA:-------------------------------------------------
POI:    I    J    DX     DY     DZ
```

```
        8    2   .000   .000   .000
LC#        FX          FY          FZ          MX          MY          MZ
 1      1.000       2.000       3.000       4.000       5.000       6.000
POI:    I    J     DX     DY     DZ
       21    8   .500   .600   .700
LC#        FX          FY          FZ          MX          MY          MZ
 1      7.000       8.000       9.000      10.000      11.000      12.000
```

Validation Problem No. 12

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   4    24     1     1     1     0     5     8
TITLE:
TEST12
MATERIAL PROPERTIES:-----------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
      30000.            .300
DIMENSIONS:--------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
 20.000  4.000   .750  1.500      1 31  7   8  11  23  26  1.000
 20.000  4.000  1.000  1.000      1 31  7  39  42  54  57  1.500
PIPE DATA:---------------------------------------------------------------
    OD     MU X-CENTER
  8.000  .000   11.000
BOLT DATA:---------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
      3       3      34      10  2.000  1.250     .750
      3       5      34      12  2.000  2.750     .750
      6       4      37      11  4.500  2.000    1.000
     29       4      60      11 18.000  2.000    1.000
CONTROL POINT DATA:------------------------------------------------------
    I    J        X        Z
    5    3    3.500    1.250
    5    5    3.500    2.750
   13    3  135.000    1.250
   13    5  135.000    2.750
   16    3  104.000    1.000
   16    5  104.000    3.000
   18    3   76.000    1.000
   18    5   76.000    3.000
   21    3   45.000    1.250
   21    5   45.000    2.750
   30    3   18.750    1.250
   30    5   18.750    2.750
   36   10    3.500    1.250
   36   12    3.500    2.750
   44   10 -135.000    1.250
```

```
    44   12 -135.000     2.750
    47   10 -104.000     1.000
    47   12 -104.000     3.000
    49   10  -76.000     1.000
    49   12  -76.000     3.000
    52   10  -45.000     1.250
    52   12  -45.000     2.750
    61   10   18.750     1.250
    61   12   18.750     2.750
 ATTACHMENT DATA:-----------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  1.000  115.0     1    1
 I-START J-START   I-END   J-END
      13       3       5       3
      13       5       5       5
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  1.000   60.0     1    1
 I-START J-START   I-END   J-END
      21       3      30       3
      21       5      30       5
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  1.000 -115.0     1    1
 I-START J-START   I-END   J-END
      44      10      36      10
      44      12      36      12
#SEG  THICK    HGT    ANG  TYPE  DIV
   2   .500  1.000  -60.0     1    1
 I-START J-START   I-END   J-END
      52      10      61      10
      52      12      61      12
#SEG  THICK    HGT    ANG  TYPE  DIV
   4   .000   .000   90.0     0    0
 I-START J-START   I-END   J-END
      16       3      18       3
      18       3      18       5
      18       5      16       5
      16       5      16       3
 RESTRAINT DATA:------------------------------------------------------
     I    J   PIN-CODE
    13    1     00100
    13    7     00100
    21    1     00100
    21    7     00100
    44    8     00100
    44   14     00100
    52    8     00100
```

```
  52   14      00100
CLAMP LOAD DATA:-----------------------------------------------------------
POI:    I    J     DX      DY      DZ
       16    3  1.000    .000   1.000
LC#         FX          FY          FZ          MX          MY          MZ
  1      1.000       2.000       3.000       4.000       5.000       6.000
BOLT LOAD DATA:------------------------------------------------------------
LOAD BOLT#
  1
LC#          FX          FY          FZ
  1       7.000       8.000       9.000
```

Validation Problem No. 13

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   3     6     2     0     1     5     3     0
TITLE:
test13
MATERIAL PROPERTIES:-------------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        30000.            .300
DIMENSIONS:----------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I  #J IB1  IB2 IB3 IB4    RAD
 30.000  5.000  1.500  1.000      0 30   5   7    9  21  23  3.000
 28.000  4.000   .750   .500      0 20   4  35   37  42  45  1.000
PIPE DATA:-----------------------------------------------------------------
   OD      MU X-CENTER
10.000   .250   11.000
BOLT DATA:-----------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
      2       2      32       7  1.000   2.000     .500
      3       4      33       8  1.500   2.500     .750
     28       3      49       7 25.000   2.000     .500
CONTROL POINT DATA:--------------------------------------------------------
    I    J       X        Z
    1    1     .500     .750
    2    5    1.100    4.500
   30    3   29.500    2.400
   31    6     .250     .850
   32    9    1.300    4.600
   50    7   27.500    2.500
ATTACHMENT DATA:-----------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   4   .000  5.000   90.0     0    0
 I-START J-START   I-END   J-END
       3       1       5       1
       5       1       5       4
```

```
      5        4        3        2
      3        2        3        1
 #SEG  THICK    HGT    ANG  TYPE  DIV
   3   .500  2.000   70.0     1    0
  I-START J-START   I-END   J-END
      9        2       20        2
     20        2       20        5
     20        5       11        5
 #SEG  THICK    HGT    ANG  TYPE  DIV
   1   .250  5.000   90.0     1    0
  I-START J-START   I-END   J-END
     24        5       24        1
  BEAM DATA:------------------------------------------------------------
   I-START J-START   I-END   J-END        W        H
         1       1      31       6   2.100    3.400
        50       9      20       5    .700     .800
         5       5       7       5    .100     .200
        42       9      45       9    .300     .400
        47       6      40       8    .500     .600
  BOLT LOAD DATA:-------------------------------------------------------
  LOAD BOLT#
    3
  LC#          FX          FY          FZ
    1       1.000       2.000       3.000
    2       4.000       5.000       6.000
```

Validation Problem No. 14

```
  #BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
      3     6     2     0     1     5     3     0
  TITLE:
  TEST14
  MATERIAL PROPERTIES:--------------------------------------------------
  YOUNG'S MODULUS  POISSON'S RATIO
          30000.            .300
  DIMENSIONS:-----------------------------------------------------------
     XMAX    ZMAX  THICK  SPACE #LAYER #I  #J IB1 IB2 IB3 IB4     RAD
   28.000  4.000   .750   .500      0 20   4   5   7  12  15   1.000
   30.000  5.000  1.500  1.000      0 30   5  27  29  41  43   3.000
  PIPE DATA:------------------------------------------------------------
      OD     MU X-CENTER
  10.000  .250   11.000
  BOLT DATA:------------------------------------------------------------
  I-START J-START   I-END   J-END       X        Z       DIA
        22       6       2       2   1.000    2.000     .500
        23       8       3       3   1.500    2.500     .750
        38       7      19       2  25.000    2.000     .500
```

```
CONTROL POINT DATA:----------------------------------------------------
     I    J        X        Z
    21    5     .500     .750
    22    9    1.100    4.500
    50    7   29.500    2.400
     1    1     .250     .850
     2    4    1.300    4.600
    20    2   27.500    2.500
ATTACHMENT DATA:-------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
  4    .000  5.000  -90.0    0    0
 I-START J-START   I-END   J-END
     23       5      25       4
     25       5      25       8
     25       8      23       6
     23       6      23       5
#SEG  THICK    HGT    ANG  TYPE  DIV
  3    .500  2.000  -70.0    1    0
 I-START J-START   I-END   J-END
     29       6      40       6
     40       6      40       9
     40       9      31       9
#SEG  THICK    HGT    ANG  TYPE  DIV
  1    .250  5.000  -90.0    1    0
 I-START J-START   I-END   J-END
     44       9      44       5
BEAM DATA:-------------------------------------------------------------
 I-START J-START   I-END   J-END       W       H
      21       5       1       1   2.100   3.400
      20       4      50       9    .700    .800
      25       9      27       9    .100    .200
      12       4      15       4    .300    .400
      17       1      10       3    .500    .600
BOLT LOAD DATA:--------------------------------------------------------
LOAD BOLT#
  3
LC#        FX          FY          FZ
  1     1.000       2.000       3.000
  2     4.000       5.000       6.000
```

Validation Problem No. 15

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    3     6     2     0     1     5     3     0
TITLE:
test15
MATERIAL PROPERTIES:---------------------------------------------------
```

```
YOUNG'S MODULUS  POISSON'S RATIO
       30000.           .300
DIMENSIONS:-----------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4    RAD
 30.000 5.000  1.500  1.000      1 30  5   7   9  21  23  3.000
 28.000 4.000   .750   .500      1 20  4  35  37  42  45  1.000
PIPE DATA:------------------------------------------------------------
    OD    MU X-CENTER
10.000  .250   11.000
BOLT DATA:------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z     DIA
      2       2      32       7  1.000  2.000    .500
      3       4      33       8  1.500  2.500    .750
     28       3      49       7 25.000  2.000    .500
CONTROL POINT DATA:---------------------------------------------------
    I    J        X        Z
    1    1     .500     .750
    2    5    1.100    4.500
   30    3   29.500    2.400
   31    6     .250     .850
   32    9    1.300    4.600
   50    7   27.500    2.500
ATTACHMENT DATA:------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
  4    .000  5.000   90.0     0    0
 I-START J-START   I-END   J-END
      3       1       5       1
      5       1       5       4
      5       4       3       2
      3       2       3       1
#SEG  THICK    HGT    ANG  TYPE  DIV
  3    .500  2.000   70.0     1    0
 I-START J-START   I-END   J-END
      9       2      20       2
     20       2      20       5
     20       5      11       5
#SEG  THICK    HGT    ANG  TYPE  DIV
  1    .250  5.000   90.0     1    0
 I-START J-START   I-END   J-END
     24       5      24       1
BEAM DATA:------------------------------------------------------------
 I-START J-START   I-END   J-END       W       H
      1       1      31       6   2.100   3.400
     50       9      20       5    .700    .800
      5       5       7       5    .100    .200
     42       9      45       9    .300    .400
```

```
     47       6      40       8    .500    .600
BOLT LOAD DATA:------------------------------------------------------------
LOAD BOLT#
  3
LC#         FX          FY          FZ
  1       1.000       2.000       3.000
  2       4.000       5.000       6.000
```

Validation Problem No. 16

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    3     6     2     0     1     5     3     0
TITLE:
TEST16
MATERIAL PROPERTIES:-------------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        30000.            .300
DIMENSIONS:----------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I #J IB1 IB2 IB3 IB4     RAD
 28.000 4.000   .750   .500      1 20  4   5   7  12  15  1.000
 30.000 5.000  1.500  1.000      1 30  5  27  29  41  43  3.000
PIPE DATA:-----------------------------------------------------------------
    OD     MU X-CENTER
10.000  .250   11.000
BOLT DATA:-----------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z      DIA
     22       6       2       2  1.000  2.000     .500
     23       8       3       3  1.500  2.500     .750
     38       7      19       2 25.000  2.000     .500
CONTROL POINT DATA:--------------------------------------------------------
    I    J        X         Z
   21    5     .500      .750
   22    9    1.100     4.500
   50    7   29.500     2.400
    1    1     .250      .850
    2    4    1.300     4.600
   20    2   27.500     2.500
ATTACHMENT DATA:-----------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
   4   .000  5.000  -90.0     0    0
I-START J-START   I-END   J-END
     23       5      25       4
     25       5      25       8
     25       8      23       6
     23       6      23       5
#SEG  THICK    HGT    ANG  TYPE  DIV
   3   .500  2.000  -70.0     1    0
```

```
I-START J-START   I-END   J-END
    29       6      40       6
    40       6      40       9
    40       9      31       9
#SEG  THICK    HGT    ANG  TYPE  DIV
   1   .250  5.000  -90.0     1    0
I-START J-START   I-END   J-END
    44       9      44       5
BEAM DATA:------------------------------------------------------------
 I-START J-START   I-END   J-END       W       H
     21       5       1       1   2.100   3.400
     20       4      50       9    .700    .800
     25       9      27       9    .100    .200
     12       4      15       4    .300    .400
     17       1      10       3    .500    .600
BOLT LOAD DATA:-------------------------------------------------------
LOAD BOLT#
  3
LC#         FX          FY          FZ
  1      1.000       2.000       3.000
  2      4.000       5.000       6.000
```

Validation Problem No. 17

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
    2     4     1     1     0     0     1     0
TITLE:
TEST17
MATERIAL PROPERTIES:--------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        30000.             .300
DIMENSIONS:-----------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I  #J  IB1  IB2  IB3  IB4    RAD
 21.500  3.000   .750  1.675      0 20   5    5    7   14   16  1.000
 21.500  3.000   .750   .875      0 20   5   25   27   34   36  1.000
PIPE DATA:------------------------------------------------------------
    OD     MU X-CENTER
12.000  .000   10.625
BOLT DATA:------------------------------------------------------------
I-START J-START   I-END   J-END       X       Z      DIA
      2       3      22       8  1.625   1.500    1.500
     19       3      39       8 19.625   1.500    1.500
CONTROL POINT DATA:---------------------------------------------------
    I    J       X        Z
    3    2   2.500    1.500
    3    4   2.000    2.800
    4    3   3.000    2.000
```

```
   17    3   18.000    1.000
 ATTACHMENT DATA:-------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
  1   .000   .000     .1     0    0
 I-START J-START   I-END   J-END
  8    3          9       3
 CLAMP LOAD DATA:-------------------------------------------------------
 POI:    I    J     DX     DY     DZ
         8    3   .000   .000   .000
 LC#         FX         FY         FZ         MX         MY         MZ
  1       1.111      2.222      3.333      4.444      5.555      6.666
```

Validation Problem No. 18

```
#BOLT #CTRL   #LC #C-PT #B-PT #BEAM  #ATT #REST
   2     4     1     1     0     0     1     0
TITLE:
TEST18
MATERIAL PROPERTIES:-----------------------------------------------------------
YOUNG'S MODULUS  POISSON'S RATIO
        30000.           .300
DIMENSIONS:-------------------------------------------------------------
   XMAX   ZMAX  THICK  SPACE #LAYER #I  #J  IB1  IB2  IB3  IB4    RAD
 21.500  3.000   .750  1.675      1 20   5    5    7   14   16  1.000
 21.500  3.000   .750   .875      1 20   5   25   27   34   36  1.000
PIPE DATA:--------------------------------------------------------------
   OD     MU X-CENTER
12.000  .000   10.625
BOLT DATA:--------------------------------------------------------------
I-START J-START   I-END   J-END      X       Z     DIA
      2       3      22       8  1.625   1.500   1.500
     19       3      39       8 19.625   1.500   1.500
CONTROL POINT DATA:-----------------------------------------------------
    I    J        X        Z
    3    2    2.500    1.500
    3    4    2.000    2.800
    4    3    3.000    2.000
   17    3   18.000    1.000
 ATTACHMENT DATA:-------------------------------------------------------
#SEG  THICK    HGT    ANG  TYPE  DIV
  1   .000   .000     .1     0    0
 I-START J-START   I-END   J-END
  8    3          9       3
 CLAMP LOAD DATA:-------------------------------------------------------
 POI:    I    J     DX     DY     DZ
```

	8 3	.000	.000	.000		
LC#	FX	FY	FZ	MX	MY	MZ
1	1.111	2.222	3.333	4.444	5.555	6.666

5 VALIDATION PROBLEM OUTPUT

Validation Problem No. 1

```
/PREP7
/TITLE TEST1
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,    1.188,     .000
N,    2,     .000,    1.188,     .750
N,    3,     .000,    1.188,    1.500
N,    4,     .000,    1.188,    2.250
N,    5,     .000,    1.188,    3.000
N,    6,    1.625,    1.188,     .000
N,    7,    1.625,    1.188,     .750
N,    8,    1.625,    1.188,    1.500
N,    9,    1.625,    1.188,    2.250
N,   10,    1.625,    1.188,    3.000
N,   11,    2.187,    1.188,     .000
N,   12,    2.187,    1.188,     .750
N,   13,    2.187,    1.188,    1.500
N,   14,    2.187,    1.188,    2.250
N,   15,    2.187,    1.188,    3.000
N,   16,    2.749,    1.188,     .000
N,   17,    2.749,    1.188,     .750
N,   18,    2.749,    1.188,    1.500
N,   19,    2.749,    1.188,    2.250
N,   20,    2.749,    1.188,    3.000
N,   21,    3.311,    1.188,     .000
N,   22,    3.311,    1.188,     .750
N,   23,    3.311,    1.188,    1.500
N,   24,    3.311,    1.188,    2.250
N,   25,    3.311,    1.188,    3.000
```

N,	76,	18.060,	.813,	.000
N,	77,	18.060,	.813,	.750
N,	78,	18.060,	.813,	1.500
N,	79,	18.060,	.813,	2.250
N,	80,	18.060,	.813,	3.000
N,	81,	18.582,	.813,	.000
N,	82,	18.582,	.813,	.750
N,	83,	18.582,	.813,	1.500
N,	84,	18.582,	.813,	2.250
N,	85,	18.582,	.813,	3.000
N,	86,	19.103,	.813,	.000
N,	87,	19.103,	.813,	.750
N,	88,	19.103,	.813,	1.500
N,	89,	19.103,	.813,	2.250
N,	90,	19.103,	.813,	3.000
N,	91,	19.625,	.813,	.000
N,	92,	19.625,	.813,	.750
N,	93,	19.625,	.813,	1.500
N,	94,	19.625,	.813,	2.250
N,	95,	19.625,	.813,	3.000
N,	96,	21.500,	.813,	.000
N,	97,	21.500,	.813,	.750
N,	98,	21.500,	.813,	1.500
N,	99,	21.500,	.813,	2.250
N,	100,	21.500,	.813,	3.000
N,	101,	.000,	-1.188,	.000
N,	102,	.000,	-1.188,	.750
N,	103,	.000,	-1.188,	1.500
N,	104,	.000,	-1.188,	2.250
N,	105,	.000,	-1.188,	3.000
N,	106,	1.625,	-1.188,	.000
N,	107,	1.625,	-1.188,	.750
N,	108,	1.625,	-1.188,	1.500
N,	109,	1.625,	-1.188,	2.250
N,	110,	1.625,	-1.188,	3.000
N,	111,	2.187,	-1.188,	.000
N,	112,	2.187,	-1.188,	.750
N,	113,	2.187,	-1.188,	1.500
N,	114,	2.187,	-1.188,	2.250
N,	115,	2.187,	-1.188,	3.000
N,	116,	2.749,	-1.188,	.000
N,	117,	2.749,	-1.188,	.750
N,	118,	2.749,	-1.188,	1.500
N,	119,	2.749,	-1.188,	2.250
N,	120,	2.749,	-1.188,	3.000
N,	121,	3.311,	-1.188,	.000

```
N,  122,    3.311,   -1.188,     .750
N,  123,    3.311,   -1.188,    1.500
N,  124,    3.311,   -1.188,    2.250
N,  125,    3.311,   -1.188,    3.000
N,  176,   18.060,    -.813,     .000
N,  177,   18.060,    -.813,     .750
N,  178,   18.060,    -.813,    1.500
N,  179,   18.060,    -.813,    2.250
N,  180,   18.060,    -.813,    3.000
N,  181,   18.582,    -.813,     .000
N,  182,   18.582,    -.813,     .750
N,  183,   18.582,    -.813,    1.500
N,  184,   18.582,    -.813,    2.250
N,  185,   18.582,    -.813,    3.000
N,  186,   19.103,    -.813,     .000
N,  187,   19.103,    -.813,     .750
N,  188,   19.103,    -.813,    1.500
N,  189,   19.103,    -.813,    2.250
N,  190,   19.103,    -.813,    3.000
N,  191,   19.625,    -.813,     .000
N,  192,   19.625,    -.813,     .750
N,  193,   19.625,    -.813,    1.500
N,  194,   19.625,    -.813,    2.250
N,  195,   19.625,    -.813,    3.000
N,  196,   21.500,    -.813,     .000
N,  197,   21.500,    -.813,     .750
N,  198,   21.500,    -.813,    1.500
N,  199,   21.500,    -.813,    2.250
N,  200,   21.500,    -.813,    3.000
CSYS, 11
N,   31,    6.375,  160.692,     .000
N,   32,    6.375,  160.692,     .750
N,   33,    6.375,  160.692,    1.500
N,   34,    6.375,  160.692,    2.250
N,   35,    6.375,  160.692,    3.000
N,   36,    6.375,  140.078,     .000
N,   37,    6.375,  140.078,     .750
N,   38,    6.375,  140.078,    1.500
N,   39,    6.375,  140.078,    2.250
N,   40,    6.375,  140.078,    3.000
N,   41,    6.375,  119.464,     .000
N,   42,    6.375,  119.464,     .750
N,   43,    6.375,  119.464,    1.500
N,   44,    6.375,  119.464,    2.250
N,   45,    6.375,  119.464,    3.000
N,   46,    6.375,   98.850,     .000
```

N,	47,	6.375,	98.850,	.750
N,	48,	6.375,	98.850,	1.500
N,	49,	6.375,	98.850,	2.250
N,	50,	6.375,	98.850,	3.000
N,	51,	6.375,	78.237,	.000
N,	52,	6.375,	78.237,	.750
N,	53,	6.375,	78.237,	1.500
N,	54,	6.375,	78.237,	2.250
N,	55,	6.375,	78.237,	3.000
N,	56,	6.375,	57.623,	.000
N,	57,	6.375,	57.623,	.750
N,	58,	6.375,	57.623,	1.500
N,	59,	6.375,	57.623,	2.250
N,	60,	6.375,	57.623,	3.000
N,	61,	6.375,	37.009,	.000
N,	62,	6.375,	37.009,	.750
N,	63,	6.375,	37.009,	1.500
N,	64,	6.375,	37.009,	2.250
N,	65,	6.375,	37.009,	3.000
N,	66,	6.375,	16.395,	.000
N,	67,	6.375,	16.395,	.750
N,	68,	6.375,	16.395,	1.500
N,	69,	6.375,	16.395,	2.250
N,	70,	6.375,	16.395,	3.000
N,	131,	6.375,	-160.692,	.000
N,	132,	6.375,	-160.692,	.750
N,	133,	6.375,	-160.692,	1.500
N,	134,	6.375,	-160.692,	2.250
N,	135,	6.375,	-160.692,	3.000
N,	136,	6.375,	-140.078,	.000
N,	137,	6.375,	-140.078,	.750
N,	138,	6.375,	-140.078,	1.500
N,	139,	6.375,	-140.078,	2.250
N,	140,	6.375,	-140.078,	3.000
N,	141,	6.375,	-119.464,	.000
N,	142,	6.375,	-119.464,	.750
N,	143,	6.375,	-119.464,	1.500
N,	144,	6.375,	-119.464,	2.250
N,	145,	6.375,	-119.464,	3.000
N,	146,	6.375,	-98.850,	.000
N,	147,	6.375,	-98.850,	.750
N,	148,	6.375,	-98.850,	1.500
N,	149,	6.375,	-98.850,	2.250
N,	150,	6.375,	-98.850,	3.000
N,	151,	6.375,	-78.237,	.000
N,	152,	6.375,	-78.237,	.750

```
N,  153,    6.375,  -78.237,    1.500
N,  154,    6.375,  -78.237,    2.250
N,  155,    6.375,  -78.237,    3.000
N,  156,    6.375,  -57.623,     .000
N,  157,    6.375,  -57.623,     .750
N,  158,    6.375,  -57.623,    1.500
N,  159,    6.375,  -57.623,    2.250
N,  160,    6.375,  -57.623,    3.000
N,  161,    6.375,  -37.009,     .000
N,  162,    6.375,  -37.009,     .750
N,  163,    6.375,  -37.009,    1.500
N,  164,    6.375,  -37.009,    2.250
N,  165,    6.375,  -37.009,    3.000
N,  166,    6.375,  -16.395,     .000
N,  167,    6.375,  -16.395,     .750
N,  168,    6.375,  -16.395,    1.500
N,  169,    6.375,  -16.395,    2.250
N,  170,    6.375,  -16.395,    3.000
CSYS, 12
N,   26,    1.375,  -54.654,     .000
N,   27,    1.375,  -54.654,     .750
N,   28,    1.375,  -54.654,    1.500
N,   29,    1.375,  -54.654,    2.250
N,   30,    1.375,  -54.654,    3.000
CSYS, 13
N,   71,    1.375, -126.802,     .000
N,   72,    1.375, -126.802,     .750
N,   73,    1.375, -126.802,    1.500
N,   74,    1.375, -126.802,    2.250
N,   75,    1.375, -126.802,    3.000
CSYS, 14
N,  126,    1.375,   54.654,     .000
N,  127,    1.375,   54.654,     .750
N,  128,    1.375,   54.654,    1.500
N,  129,    1.375,   54.654,    2.250
N,  130,    1.375,   54.654,    3.000
CSYS, 15
N,  171,    1.375,  126.802,     .000
N,  172,    1.375,  126.802,     .750
N,  173,    1.375,  126.802,    1.500
N,  174,    1.375,  126.802,    2.250
N,  175,    1.375,  126.802,    3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  202,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   32,   67,    5, -.1000,  .0000,  .0000
```

```
NGEN ,    2,  202,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   34,   69,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2,  202,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  201,    1.625,     .000,    1.500
N,  202,   19.625,     .000,    1.500
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .750
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E,  101,  102,  107,  106
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 233,  31
EGEN,   8,   5, 153, 153,   1
EGEN,   5,   1, 153, 160,   1
E, 333, 131
EGEN,   8,   5, 193, 193,   1
EGEN,   5,   1, 193, 200,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   4,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,   4
E ,    8,  201
E ,  201,  108
```

```
E ,   93,  202
E ,  202,  193
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  233, ALL, 0.0,, 268,   5
D,  234, ALL, 0.0,, 269,   5
D,  235, ALL, 0.0,, 270,   5
D,  236, ALL, 0.0,, 271,   5
D,  237, ALL, 0.0,, 272,   5
D,  333, ALL, 0.0,, 368,   5
D,  334, ALL, 0.0,, 369,   5
D,  335, ALL, 0.0,, 370,   5
D,  336, ALL, 0.0,, 371,   5
D,  337, ALL, 0.0,, 372,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  201,FX,       -9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

Validation Problem No. 2

```
/PREP7
/TITLE TEST2
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,      29000.000
NUXY, 1,  .200
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,    1.188,     .000
N,    2,     .000,    1.188,     .500
N,    3,     .000,    1.188,    1.000
N,    4,     .000,    1.188,    1.500
N,    5,     .000,    1.188,    2.000
N,    6,     .000,    1.188,    2.500
N,    7,     .000,    1.188,    3.000
N,    8,    1.625,    1.188,     .000
N,    9,    1.625,    1.188,     .500
N,   10,    1.625,    1.188,    1.000
N,   11,    1.625,    1.188,    1.500
N,   12,    1.625,    1.188,    2.000
N,   13,    1.625,    1.188,    2.500
N,   14,    1.625,    1.188,    3.000
N,   15,    2.046,    1.188,     .000
N,   16,    2.046,    1.188,     .500
N,   17,    2.046,    1.188,    1.000
N,   18,    2.046,    1.188,    1.500
N,   19,    2.046,    1.188,    2.000
N,   20,    2.046,    1.188,    2.500
N,   21,    2.046,    1.188,    3.000
N,   22,    2.468,    1.188,     .000
N,   23,    2.468,    1.188,     .500
N,   24,    2.468,    1.188,    1.000
N,   25,    2.468,    1.188,    1.500
N,   26,    2.468,    1.188,    2.000
N,   27,    2.468,    1.188,    2.500
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N,	28,	2.468,	1.188,	3.000
N,	29,	2.889,	1.188,	.000
N,	30,	2.889,	1.188,	.500
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N,	34,	2.889,	1.188,	2.500
N,	35,	2.889,	1.188,	3.000
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N,	37,	3.311,	1.188,	.500
N,	38,	3.311,	1.188,	1.000
N,	39,	3.311,	1.188,	1.500
N,	40,	3.311,	1.188,	2.000
N,	41,	3.311,	1.188,	2.500
N,	42,	3.311,	1.188,	3.000
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N,	143,	18.060,	.813,	1.000
N,	144,	18.060,	.813,	1.500
N,	145,	18.060,	.813,	2.000
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N,	147,	18.060,	.813,	3.000
N,	148,	18.373,	.813,	.000
N,	149,	18.373,	.813,	.500
N,	150,	18.373,	.813,	1.000
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N,	156,	18.686,	.813,	.500
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N,	174,	19.312,	.813,	2.500
N,	175,	19.312,	.813,	3.000
N,	176,	19.625,	.813,	.000
N,	177,	19.625,	.813,	.500
N,	178,	19.625,	.813,	1.000
N,	179,	19.625,	.813,	1.500
N,	180,	19.625,	.813,	2.000
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N,	184,	21.500,	.813,	.500
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N,	186,	21.500,	.813,	1.500
N,	187,	21.500,	.813,	2.000
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N,	189,	21.500,	.813,	3.000
N,	190,	.000,	-1.188,	.000
N,	191,	.000,	-1.188,	.750
N,	192,	.000,	-1.188,	1.500
N,	193,	.000,	-1.188,	2.250
N,	194,	.000,	-1.188,	3.000
N,	195,	.813,	-1.188,	.000
N,	196,	.813,	-1.188,	.750
N,	197,	.813,	-1.188,	1.500
N,	198,	.813,	-1.188,	2.250
N,	199,	.813,	-1.188,	3.000
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N,	201,	1.625,	-1.188,	.750
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N,	203,	1.625,	-1.188,	2.250
N,	204,	1.625,	-1.188,	3.000
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N,	206,	2.187,	-1.188,	.750
N,	207,	2.187,	-1.188,	1.500
N,	208,	2.187,	-1.188,	2.250
N,	209,	2.187,	-1.188,	3.000
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N,	212,	2.749,	-1.188,	1.500
N,	213,	2.749,	-1.188,	2.250
N,	214,	2.749,	-1.188,	3.000
N,	215,	3.311,	-1.188,	.000
N,	216,	3.311,	-1.188,	.750
N,	217,	3.311,	-1.188,	1.500

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N,  218,   3.311,  -1.188,   2.250
N,  219,   3.311,  -1.188,   3.000
N,  255,  18.060,   -.813,    .000
N,  256,  18.060,   -.813,    .750
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N,  264,  18.842,   -.813,   3.000
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N,  269,  19.625,   -.813,   3.000
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N,  271,  21.500,   -.813,    .750
N,  272,  21.500,   -.813,   1.500
N,  273,  21.500,   -.813,   2.250
N,  274,  21.500,   -.813,   3.000
CSYS, 11
N,    50,    6.375, 160.692,    .000
N,    51,    6.375, 160.692,    .500
N,    52,    6.375, 160.692,   1.000
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N,    62,    6.375, 146.262,   2.500
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N,    65,    6.375, 131.833,    .500
N,    66,    6.375, 131.833,   1.000
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N,    70,    6.375, 131.833,   3.000
N,    71,    6.375, 117.403,    .000
N,    72,    6.375, 117.403,    .500
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N,  74,  6.375, 117.403,  1.500
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N, 100,  6.375,  59.684,   .500
N, 101,  6.375,  59.684,  1.000
N, 102,  6.375,  59.684,  1.500
N, 103,  6.375,  59.684,  2.000
N, 104,  6.375,  59.684,  2.500
N, 105,  6.375,  59.684,  3.000
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N, 107,  6.375,  45.254,   .500
N, 108,  6.375,  45.254,  1.000
N, 109,  6.375,  45.254,  1.500
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N, 112,  6.375,  45.254,  3.000
N, 113,  6.375,  30.825,   .000
N, 114,  6.375,  30.825,   .500
N, 115,  6.375,  30.825,  1.000
N, 116,  6.375,  30.825,  1.500
N, 117,  6.375,  30.825,  2.000
N, 118,  6.375,  30.825,  2.500
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N,  119,   6.375,   30.825,    3.000
N,  120,   6.375,   16.395,     .000
N,  121,   6.375,   16.395,     .500
N,  122,   6.375,   16.395,    1.000
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N,  126,   6.375,   16.395,    3.000
N,  220,   6.375, -160.692,     .000
N,  221,   6.375, -160.692,     .750
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N,  223,   6.375, -160.692,    2.250
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N,  226,   6.375, -131.833,     .750
N,  227,   6.375, -131.833,    1.500
N,  228,   6.375, -131.833,    2.250
N,  229,   6.375, -131.833,    3.000
N,  230,   6.375, -102.973,     .000
N,  231,   6.375, -102.973,     .750
N,  232,   6.375, -102.973,    1.500
N,  233,   6.375, -102.973,    2.250
N,  234,   6.375, -102.973,    3.000
N,  235,   6.375,  -74.114,     .000
N,  236,   6.375,  -74.114,     .750
N,  237,   6.375,  -74.114,    1.500
N,  238,   6.375,  -74.114,    2.250
N,  239,   6.375,  -74.114,    3.000
N,  240,   6.375,  -45.254,     .000
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N,  243,   6.375,  -45.254,    2.250
N,  244,   6.375,  -45.254,    3.000
N,  245,   6.375,  -16.395,     .000
N,  246,   6.375,  -16.395,     .750
N,  247,   6.375,  -16.395,    1.500
N,  248,   6.375,  -16.395,    2.250
N,  249,   6.375,  -16.395,    3.000
 CSYS, 12
 N,   43,   1.375,  -54.654,     .000
 N,   44,   1.375,  -54.654,     .500
 N,   45,   1.375,  -54.654,    1.000
 N,   46,   1.375,  -54.654,    1.500
 N,   47,   1.375,  -54.654,    2.000
 N,   48,   1.375,  -54.654,    2.500
 N,   49,   1.375,  -54.654,    3.000
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CSYS, 13
N, 127,    1.375, -139.070,     .000
N, 128,    1.375, -139.070,     .500
N, 129,    1.375, -139.070,    1.000
N, 130,    1.375, -139.070,    1.500
N, 131,    1.375, -139.070,    2.000
N, 132,    1.375, -139.070,    2.500
N, 133,    1.375, -139.070,    3.000
N, 134,    1.375, -114.535,     .000
N, 135,    1.375, -114.535,     .500
N, 136,    1.375, -114.535,    1.000
N, 137,    1.375, -114.535,    1.500
N, 138,    1.375, -114.535,    2.000
N, 139,    1.375, -114.535,    2.500
N, 140,    1.375, -114.535,    3.000
CSYS, 14
CSYS, 15
N, 250,    1.375,  126.802,     .000
N, 251,    1.375,  126.802,     .750
N, 252,    1.375,  126.802,    1.500
N, 253,    1.375,  126.802,    2.250
N, 254,    1.375,  126.802,    3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,   2, 276,  50, 120,   7, -.1000,  .0000,  .0000
NGEN ,   2, 276,  51, 121,   7, -.1000,  .0000,  .0000
NGEN ,   2, 276,  52, 122,   7, -.1000,  .0000,  .0000
NGEN ,   2, 276,  53, 123,   7, -.1000,  .0000,  .0000
NGEN ,   2, 276,  54, 124,   7, -.1000,  .0000,  .0000
NGEN ,   2, 276,  55, 125,   7, -.1000,  .0000,  .0000
NGEN ,   2, 276,  56, 126,   7, -.1000,  .0000,  .0000
NGEN ,   2, 276, 220, 245,   5, -.1000,  .0000,  .0000
NGEN ,   2, 276, 221, 246,   5, -.1000,  .0000,  .0000
NGEN ,   2, 276, 222, 247,   5, -.1000,  .0000,  .0000
NGEN ,   2, 276, 223, 248,   5, -.1000,  .0000,  .0000
NGEN ,   2, 276, 224, 249,   5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS, 0
N, 275,   1.625,    .000,   1.500
N, 276,  19.625,    .000,   1.500
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .750
REAL, 1
E,   1,   2,   9,   8
```

```
EGEN,   6,    1,    1,    1,    1
EGEN,  26,    7,    1,    6,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E,  190,  191,  196,  195
EGEN,   4,    1,  157,  157,    1
EGEN,  16,    5,  157,  160,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 326,  50
EGEN,  11,   7, 221, 221,   1
EGEN,   7,   1, 221, 231,   1
E, 496, 220
EGEN,   6,   5, 298, 298,   1
EGEN,   5,   1, 298, 303,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  4,   1.7671,    .2485,    .2485,   1.5000,   1.5000,,,    .4970
REAL,  4
E ,   11,  275
E ,  275,  202
E ,  179,  276
E ,  276,  267
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  326, ALL, 0.0,, 396,   7
D,  327, ALL, 0.0,, 397,   7
D,  328, ALL, 0.0,, 398,   7
D,  329, ALL, 0.0,, 399,   7
D,  330, ALL, 0.0,, 400,   7
D,  331, ALL, 0.0,, 401,   7
D,  332, ALL, 0.0,, 402,   7
D,  496, ALL, 0.0,, 521,   5
D,  497, ALL, 0.0,, 522,   5
D,  498, ALL, 0.0,, 523,   5
D,  499, ALL, 0.0,, 524,   5
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D,  500, ALL, 0.0,, 525,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  275,FX,      -9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

Validation Problem No. 3

```
/PREP7
/TITLE TEST3
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     29000.000
NUXY, 1,  .330
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,    1.188,     .000
N,    2,     .000,    1.188,     .750
N,    3,     .000,    1.188,    1.500
N,    4,     .000,    1.188,    2.250
N,    5,     .000,    1.188,    3.000
N,    6,     .813,    1.188,     .000
N,    7,     .813,    1.188,     .750
N,    8,     .813,    1.188,    1.500
N,    9,     .813,    1.188,    2.250
N,   10,     .813,    1.188,    3.000
N,   11,    1.625,    1.188,     .000
N,   12,    1.625,    1.188,     .750
N,   13,    1.625,    1.188,    1.500
N,   14,    1.625,    1.188,    2.250
N,   15,    1.625,    1.188,    3.000
N,   16,    2.187,    1.188,     .000
N,   17,    2.187,    1.188,     .750
N,   18,    2.187,    1.188,    1.500
N,   19,    2.187,    1.188,    2.250
N,   20,    2.187,    1.188,    3.000
N,   21,    2.749,    1.188,     .000
N,   22,    2.749,    1.188,     .750
N,   23,    2.749,    1.188,    1.500
N,   24,    2.749,    1.188,    2.250
N,   25,    2.749,    1.188,    3.000
N,   26,    3.311,    1.188,     .000
N,   27,    3.311,    1.188,     .750
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N,  28,   3.311,   1.188,  1.500
N,  29,   3.311,   1.188,  2.250
N,  30,   3.311,   1.188,  3.000
N, 101,  18.060,    .813,   .000
N, 102,  18.060,    .813,   .500
N, 103,  18.060,    .813,  1.500
N, 104,  18.060,    .813,  2.500
N, 105,  18.060,    .813,  3.000
N, 106,  18.842,    .813,   .000
N, 107,  18.842,    .813,   .500
N, 108,  18.842,    .813,  1.500
N, 109,  18.842,    .813,  2.500
N, 110,  18.842,    .813,  3.000
N, 111,  19.625,    .813,   .000
N, 112,  19.625,    .813,   .500
N, 113,  19.625,    .813,  1.500
N, 114,  19.625,    .813,  2.500
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CSYS, 12
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N,  32,    1.375,  -54.654,     .750
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N,  34,    1.375,  -54.654,    2.250
N,  35,    1.375,  -54.654,    3.000
CSYS, 13
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CSYS, 14
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N, 142,    1.375,   66.436,     .625
N, 143,    1.375,   66.436,    1.500
N, 144,    1.375,   66.436,    2.375
N, 145,    1.375,   66.436,    3.000
N, 146,    1.375,   42.872,     .000
N, 147,    1.375,   42.872,     .625
N, 148,    1.375,   42.872,    1.500
N, 149,    1.375,   42.872,    2.375
N, 150,    1.375,   42.872,    3.000
CSYS, 15
N, 216,    1.375,  126.802,     .000
N, 217,    1.375,  126.802,    1.000
N, 218,    1.375,  126.802,    1.500
N, 219,    1.375,  126.802,    2.000
N, 220,    1.375,  126.802,    3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  289,   36,   86,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,   37,   87,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,   38,   88,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,   39,   89,    5, -.1000,  .0000,  .0000
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NGEN ,    2,  289,  154,  214,    5, -.1000,  .0000,  .0000
NGEN ,    2,  289,  155,  215,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
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N,  251,    6.117,    8.749,    2.250
N,  252,    5.403,    6.203,    1.500
N,  253,    5.404,    8.750,    1.500
N,  254,   16.762,    7.547,    1.500
N,  255,   17.467,    6.842,    2.500
N,  256,   18.557,    5.751,    1.500
N,  257,   17.467,    6.842,     .500
N,  258,    6.067,   -5.238,    1.500
N,  259,    5.425,   -4.520,     .625
N,  260,    5.165,   -5.254,    1.500
N,  261,    4.733,   -4.532,     .625
N,  262,    4.263,   -5.269,    1.500
N,  263,    4.041,   -4.544,     .625
N,  264,    3.361,   -5.285,    1.500
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N,  267,    4.733,   -4.532,    2.375
N,  268,    4.041,   -4.544,    2.375
N,  269,    3.349,   -4.556,    2.375
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N,  272,    3.851,   -3.684,    1.500
N,  273,    3.334,   -3.693,    1.500
N,  274,   15.564,   -5.917,    2.000
N,  275,   14.949,   -6.530,    1.500
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N,  277,   15.349,   -7.637,    1.500
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N, 289,   6.753,   -6.404,    1.500
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TYPE, 2
MAT, 1
R, 1,    .750
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   23,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E,  121,  122,  127,  126
EGEN,    4,    1,   93,   93,    1
EGEN,   24,    5,   93,   96,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 325,  36
EGEN,  11,   5, 189, 189,   1
EGEN,   5,   1, 189, 199,   1
E, 440, 151
EGEN,  13,   5, 244, 244,   1
EGEN,   5,   1, 244, 256,   1
/COM *****ATTACHMENT QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R,  4,  .100
REAL,  4
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E,  246,  247,  249,  248
E,   53,   49,  250,  247
E,  247,  250,  251,  249
E,   49,   43,  252,  250
E,  250,  252,  253,  251
E,   43,   47,  246,  252
E,  252,  246,  248,  253
R,  5,  .200
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REAL, 5
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E,  79,  83, 256, 255
E,  83,  77, 257, 256
E,  77,  73, 254, 257
R, 6, .300
REAL, 6
E, 168, 162, 259, 258
E, 258, 259, 261, 260
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E, 168, 164, 266, 258
E, 258, 266, 267, 260
E, 260, 267, 268, 262
E, 262, 268, 269, 264
E, 158, 162, 259, 270
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E, 158, 164, 266, 270
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E, 272, 268, 269, 273
R, 7, .400
REAL, 7
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E, 274, 275, 277, 276
E, 276, 277, 279, 278
E, 202, 198, 275, 280
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E, 281, 277, 279, 282
E, 204, 208, 283, 274
E, 274, 283, 284, 276
E, 276, 284, 285, 278
E, 202, 208, 283, 280
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E, 281, 284, 285, 282
/COM *****BEAM AND BOLT MEMBERS*****
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MAT, 1
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E , 248, 249
E , 249, 251
E , 251, 253
E , 253, 248
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E ,  264,  265
E ,  264,  269
E ,  273,  265
E ,  273,  269
R,   9,    1.7671,     .2485,     .2485,     1.5000,     1.5000,,,     .4970
REAL,   9
E ,    13,  286
E ,  286,  128
R,  10,     .7854,     .0491,     .0491,     1.0000,     1.0000,,,     .0982
REAL,  10
E ,  113,  287
E ,  287,  233
R,  11,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  11
E ,  248,  288
E ,  264,  289
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  325, ALL, 0.0,, 375,   5
D,  326, ALL, 0.0,, 376,   5
D,  327, ALL, 0.0,, 377,   5
D,  328, ALL, 0.0,, 378,   5
D,  329, ALL, 0.0,, 379,   5
D,  440, ALL, 0.0,, 500,   5
D,  441, ALL, 0.0,, 501,   5
D,  442, ALL, 0.0,, 502,   5
D,  443, ALL, 0.0,, 503,   5
D,  444, ALL, 0.0,, 504,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
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F,  288,FY,       2.000
F,  288,FZ,       3.000
F,  288,MX,       4.000
F,  288,MY,       5.000
F,  288,MZ,       6.000
F,  289,FX,       7.000
F,  289,FY,       8.000
F,  289,FZ,       9.000
F,  289,MX,      10.000
F,  289,MY,      11.000
F,  289,MZ,      12.000
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LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 4

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RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     29999.000
NUXY, 1,  .340
MU, 2,  .150
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,   1,    .000,   1.188,    .000
N,   2,    .000,   1.188,    .750
N,   3,    .000,   1.188,   1.500
N,   4,    .000,   1.188,   2.250
N,   5,    .000,   1.188,   3.000
N,   6,   1.625,   1.188,    .000
N,   7,   1.625,   1.188,    .750
N,   8,   1.625,   1.188,   1.500
N,   9,   1.625,   1.188,   2.250
N,  10,   1.625,   1.188,   3.000
N,  11,   2.187,   1.188,    .000
N,  12,   2.187,   1.188,    .750
N,  13,   2.187,   1.188,   1.500
N,  14,   2.187,   1.188,   2.250
N,  15,   2.187,   1.188,   3.000
N,  16,   2.749,   1.188,    .000
N,  17,   2.749,   1.188,    .750
N,  18,   2.749,   1.188,   1.500
N,  19,   2.749,   1.188,   2.250
N,  20,   2.749,   1.188,   3.000
N,  21,   3.311,   1.188,    .000
N,  22,   3.311,   1.188,    .750
N,  23,   3.311,   1.188,   1.500
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N,  77,  18.060,    .813,    .750
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N,  87,  19.103,    .813,   .750
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N,  90,  19.103,    .813,  3.000
N,  91,  19.625,    .813,   .000
N,  92,  19.625,    .813,   .750
N,  93,  19.625,    .813,  1.500
N,  94,  19.625,    .813,  2.250
N,  95,  19.625,    .813,  3.000
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N, 123,   3.311,  -1.188,  1.500
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N,   33,    6.375,  160.692,    1.500
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N,   37,    6.375,  140.078,     .750
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N,  67,   6.375,   16.395,    .750
N,  68,   6.375,   16.395,   1.500
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N, 135,   6.375, -160.692,   3.000
N, 136,   6.375, -140.078,    .000
N, 137,   6.375, -140.078,    .750
N, 138,   6.375, -140.078,   1.500
N, 139,   6.375, -140.078,   2.250
N, 140,   6.375, -140.078,   3.000
N, 141,   6.375, -119.464,    .000
N, 142,   6.375, -119.464,    .750
N, 143,   6.375, -119.464,   1.500
N, 144,   6.375, -119.464,   2.250
N, 145,   6.375, -119.464,   3.000
N, 146,   6.375,  -98.850,    .000
N, 147,   6.375,  -98.850,    .750
N, 148,   6.375,  -98.850,   1.500
N, 149,   6.375,  -98.850,   2.250
N, 150,   6.375,  -98.850,   3.000
N, 151,   6.375,  -78.237,    .000
N, 152,   6.375,  -78.237,    .750
N, 153,   6.375,  -78.237,   1.500
N, 154,   6.375,  -78.237,   2.250
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N,  155,    6.375,  -78.237,    3.000
N,  156,    6.375,  -57.623,     .000
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N,  160,    6.375,  -57.623,    3.000
N,  161,    6.375,  -37.009,     .000
N,  162,    6.375,  -37.009,     .750
N,  163,    6.375,  -37.009,    1.500
N,  164,    6.375,  -37.009,    2.250
N,  165,    6.375,  -37.009,    3.000
N,  166,    6.375,  -16.395,     .000
N,  167,    6.375,  -16.395,     .750
N,  168,    6.375,  -16.395,    1.500
N,  169,    6.375,  -16.395,    2.250
N,  170,    6.375,  -16.395,    3.000
CSYS, 12
N,   26,    1.375,  -54.654,     .000
N,   27,    1.375,  -54.654,     .750
N,   28,    1.375,  -54.654,    1.500
N,   29,    1.375,  -54.654,    2.250
N,   30,    1.375,  -54.654,    3.000
CSYS, 13
N,   71,    1.375, -126.802,     .000
N,   72,    1.375, -126.802,     .750
N,   73,    1.375, -126.802,    1.500
N,   74,    1.375, -126.802,    2.250
N,   75,    1.375, -126.802,    3.000
CSYS, 14
N,  126,    1.375,   54.654,     .000
N,  127,    1.375,   54.654,     .750
N,  128,    1.375,   54.654,    1.500
N,  129,    1.375,   54.654,    2.250
N,  130,    1.375,   54.654,    3.000
CSYS, 15
N,  171,    1.375,  126.802,     .000
N,  172,    1.375,  126.802,     .750
N,  173,    1.375,  126.802,    1.500
N,  174,    1.375,  126.802,    2.250
N,  175,    1.375,  126.802,    3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  203,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,   34,   69,    5, -.1000,  .0000,  .0000
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NGEN ,    2,  203,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  201,    1.625,     .000,    1.500
N,  202,   19.625,     .000,    1.500
N,  203,   17.101,   12.708,    8.600
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .750
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E, 101,  102,  107,  106
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 234,  31
EGEN,   8,    5, 153, 153,    1
EGEN,   5,    1, 153, 160,    1
E, 334, 131
EGEN,   8,    5, 193, 193,    1
EGEN,   5,    1, 193, 200,    1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   4,    1.3200,    .1331,    .1584,    1.2000,    1.1000,,,     .3131
REAL,   4
E ,   11,   41
E ,   15,   45
R,   5,    4.6200,   1.6978,   1.8634,    2.2000,    2.1000,,,    3.9933
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REAL,   5
E ,  111,  141
R,   6,    5.5200,    2.4334,    2.6496,    2.4000,    2.3000,,,    5.7234
REAL,   6
E ,  115,  145
R,   7,    6.0000,    3.1250,    2.8800,    2.4000,    2.5000,,,    6.7738
REAL,   7
E ,   86,   61
R,   8,    8.1200,    5.6908,    5.3051,    2.8000,    2.9000,,,   12.4775
REAL,   8
E ,   90,   65
R,   9,    1.3200,     .1331,     .1584,    1.2000,    1.1000,,,     .3131
REAL,   9
E ,  186,  161
E ,  190,  165
R,  10,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  10
E ,   53,   59
E ,   59,   65
R,  11,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,  11
E ,    8,  201
E ,  201,  108
E ,   93,  202
E ,  202,  193
R,  12,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  12
E ,   53,  203
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  234, ALL, 0.0,, 269,   5
D,  235, ALL, 0.0,, 270,   5
D,  236, ALL, 0.0,, 271,   5
D,  237, ALL, 0.0,, 272,   5
D,  238, ALL, 0.0,, 273,   5
D,  334, ALL, 0.0,, 369,   5
D,  335, ALL, 0.0,, 370,   5
D,  336, ALL, 0.0,, 371,   5
D,  337, ALL, 0.0,, 372,   5
D,  338, ALL, 0.0,, 373,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
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F,  203,FX,       1.111
F,  203,FY,       2.222
F,  203,FZ,       3.333
F,  203,MX,       4.444
F,  203,MY,       5.555
F,  203,MZ,       6.666
LWRITE
/COM *****LOAD CASE NO.  2*****
FDELE,  203,FX
FDELE,  203,FY
FDELE,  203,FZ
FDELE,  203,MX
FDELE,  203,MY
FDELE,  203,MZ
F,  203,FX,      -1.111
F,  203,FY,      -2.222
F,  203,FZ,      -3.333
F,  203,MX,      -4.444
F,  203,MY,      -5.555
F,  203,MZ,      -6.666
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 5

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/PREP7
/TITLE TEST5
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.774,   1.438, 0.0
LOCAL, 13, 1,  17.386,   1.813, 0.0
LOCAL, 14, 1,   2.825,  -2.688, 0.0
LOCAL, 15, 1,  18.286,  -3.063, 0.0
CSYS, 0
N,    1,     .000,     .688,     .000
N,    2,     .000,     .688,     .750
N,    3,     .000,     .688,    1.500
N,    4,     .000,     .688,    2.250
N,    5,     .000,     .688,    3.000
N,    6,    1.625,     .688,     .000
N,    7,    1.625,     .688,     .750
N,    8,    1.625,     .688,    1.500
N,    9,    1.625,     .688,    2.250
N,   10,    1.625,     .688,    3.000
N,   11,    2.341,     .688,     .000
N,   12,    2.341,     .688,     .750
N,   13,    2.341,     .688,    1.500
N,   14,    2.341,     .688,    2.250
N,   15,    2.341,     .688,    3.000
N,   16,    3.058,     .688,     .000
N,   17,    3.058,     .688,     .750
N,   18,    3.058,     .688,    1.500
N,   19,    3.058,     .688,    2.250
N,   20,    3.058,     .688,    3.000
N,   21,    3.774,     .688,     .000
N,   22,    3.774,     .688,     .750
N,   23,    3.774,     .688,    1.500
N,   24,    3.774,     .688,    2.250
N,   25,    3.774,     .688,    3.000
N,   76,   17.386,    1.063,     .000
N,   77,   17.386,    1.063,     .750
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N,	78,	17.386,	1.063,	1.500
N,	79,	17.386,	1.063,	2.250
N,	80,	17.386,	1.063,	3.000
N,	81,	18.133,	1.063,	.000
N,	82,	18.133,	1.063,	.750
N,	83,	18.133,	1.063,	1.500
N,	84,	18.133,	1.063,	2.250
N,	85,	18.133,	1.063,	3.000
N,	86,	18.879,	1.063,	.000
N,	87,	18.879,	1.063,	.750
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N,	89,	18.879,	1.063,	2.250
N,	90,	18.879,	1.063,	3.000
N,	91,	19.625,	1.063,	.000
N,	92,	19.625,	1.063,	.750
N,	93,	19.625,	1.063,	1.500
N,	94,	19.625,	1.063,	2.250
N,	95,	19.625,	1.063,	3.000
N,	96,	21.500,	1.063,	.000
N,	97,	21.500,	1.063,	.750
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N,	100,	21.500,	1.063,	3.000
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N,	103,	.000,	-.813,	1.500
N,	104,	.000,	-.813,	2.250
N,	105,	.000,	-.813,	3.000
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N,	110,	1.625,	-.813,	3.000
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N,	112,	2.025,	-.813,	.750
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N,	115,	2.025,	-.813,	3.000
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N,	117,	2.425,	-.813,	.750
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N,	122,	2.825,	-.813,	.750
N,	123,	2.825,	-.813,	1.500

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N, 199,  21.500,  -1.188,  2.250
N, 200,  21.500,  -1.188,  3.000
CSYS, 11
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N,  39,   6.250, 146.272,  2.250
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N,  46,   6.250, 102.517,   .000
N,  47,   6.250, 102.517,   .750
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N,	60,	6.250,	58.762,	3.000
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N,	63,	6.250,	36.884,	1.500
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N,	65,	6.250,	36.884,	3.000
N,	66,	6.250,	15.007,	.000
N,	67,	6.250,	15.007,	.750
N,	68,	6.250,	15.007,	1.500
N,	69,	6.250,	15.007,	2.250
N,	70,	6.250,	15.007,	3.000
N,	131,	6.375,	-160.988,	.000
N,	132,	6.375,	-160.988,	.750
N,	133,	6.375,	-160.988,	1.500
N,	134,	6.375,	-160.988,	2.250
N,	135,	6.375,	-160.988,	3.000
N,	136,	6.375,	-141.103,	.000
N,	137,	6.375,	-141.103,	.750
N,	138,	6.375,	-141.103,	1.500
N,	139,	6.375,	-141.103,	2.250
N,	140,	6.375,	-141.103,	3.000
N,	141,	6.375,	-121.218,	.000
N,	142,	6.375,	-121.218,	.750
N,	143,	6.375,	-121.218,	1.500
N,	144,	6.375,	-121.218,	2.250
N,	145,	6.375,	-121.218,	3.000
N,	146,	6.375,	-101.332,	.000
N,	147,	6.375,	-101.332,	.750
N,	148,	6.375,	-101.332,	1.500
N,	149,	6.375,	-101.332,	2.250
N,	150,	6.375,	-101.332,	3.000
N,	151,	6.375,	-81.447,	.000
N,	152,	6.375,	-81.447,	.750
N,	153,	6.375,	-81.447,	1.500
N,	154,	6.375,	-81.447,	2.250

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N,  155,    6.375,  -81.447,    3.000
N,  156,    6.375,  -61.561,     .000
N,  157,    6.375,  -61.561,     .750
N,  158,    6.375,  -61.561,    1.500
N,  159,    6.375,  -61.561,    2.250
N,  160,    6.375,  -61.561,    3.000
N,  161,    6.375,  -41.676,     .000
N,  162,    6.375,  -41.676,     .750
N,  163,    6.375,  -41.676,    1.500
N,  164,    6.375,  -41.676,    2.250
N,  165,    6.375,  -41.676,    3.000
N,  166,    6.375,  -21.790,     .000
N,  167,    6.375,  -21.790,     .750
N,  168,    6.375,  -21.790,    1.500
N,  169,    6.375,  -21.790,    2.250
N,  170,    6.375,  -21.790,    3.000
CSYS, 12
N,   26,     .750,  -50.925,     .000
N,   27,     .750,  -50.925,     .750
N,   28,     .750,  -50.925,    1.500
N,   29,     .750,  -50.925,    2.250
N,   30,     .750,  -50.925,    3.000
CSYS, 13
N,   71,     .750, -127.497,     .000
N,   72,     .750, -127.497,     .750
N,   73,     .750, -127.497,    1.500
N,   74,     .750, -127.497,    2.250
N,   75,     .750, -127.497,    3.000
CSYS, 14
N,  126,    1.875,   54.506,     .000
N,  127,    1.875,   54.506,     .750
N,  128,    1.875,   54.506,    1.500
N,  129,    1.875,   54.506,    2.250
N,  130,    1.875,   54.506,    3.000
CSYS, 15
N,  171,    1.875,  124.105,     .000
N,  172,    1.875,  124.105,     .750
N,  173,    1.875,  124.105,    1.500
N,  174,    1.875,  124.105,    2.250
N,  175,    1.875,  124.105,    3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2, 275,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2, 275,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2, 275,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2, 275,   34,   69,    5, -.1000,  .0000,  .0000
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NGEN ,    2,  275,   35,   70,     5, -.1000,  .0000,  .0000
NGEN ,    2,  275,  131,  166,     5, -.1000,  .0000,  .0000
NGEN ,    2,  275,  132,  167,     5, -.1000,  .0000,  .0000
NGEN ,    2,  275,  133,  168,     5, -.1000,  .0000,  .0000
NGEN ,    2,  275,  134,  169,     5, -.1000,  .0000,  .0000
NGEN ,    2,  275,  135,  170,     5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  201,    5.427,    7.134,      .750
N,  202,    7.093,    7.133,     1.500
N,  203,    9.268,    7.131,     2.250
N,  204,   11.639,    7.128,     2.250
N,  205,   13.864,    7.126,     2.250
N,  206,   15.624,    7.124,     2.250
N,  207,   15.624,    7.124,     1.500
N,  208,   15.624,    7.124,      .750
N,  209,   15.624,    7.124,      .000
N,  210,   13.864,    7.126,      .000
N,  211,   11.639,    7.128,      .000
N,  212,     .000,   -3.605,     1.500
N,  213,    1.625,   -3.605,     1.500
N,  214,     .000,   -6.396,     1.500
N,  215,    1.625,   -6.397,     1.500
N,  216,     .000,   -9.188,     1.500
N,  217,    1.625,   -9.190,     1.500
N,  218,    2.025,   -3.605,     1.500
N,  219,    2.025,   -6.398,     1.500
N,  220,    2.025,   -9.190,     1.500
N,  221,    2.425,   -3.605,     1.500
N,  222,    2.425,   -6.398,     1.500
N,  223,    2.425,   -9.190,     1.500
N,  224,    2.825,   -3.606,     1.500
N,  225,    2.825,   -6.398,     1.500
N,  226,    2.825,   -9.191,     1.500
N,  227,    3.914,   -3.838,     1.500
N,  228,    3.914,   -6.515,     1.500
N,  229,    3.914,   -9.192,     1.500
N,  230,    4.598,   -4.449,     1.500
N,  231,    4.599,   -6.821,     1.500
N,  232,    4.599,   -9.193,     1.500
N,  233,    5.665,   -5.733,     1.500
N,  234,    5.666,   -7.463,     1.500
N,  235,    5.667,   -9.194,     1.500
N,  236,    7.322,   -6.700,     1.500
N,  237,    7.324,   -7.948,     1.500
N,  238,    7.325,   -9.195,     1.500
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N, 239,   9.374,  -7.233,   1.500
N, 240,   9.376,  -8.215,   1.500
N, 241,   9.378,  -9.197,   1.500
N, 242,  11.575,  -7.269,   1.500
N, 243,  11.577,  -8.234,   1.500
N, 244,  11.579,  -9.200,   1.500
N, 245,  13.663,  -6.804,   1.500
N, 246,  13.664,  -8.003,   1.500
N, 247,  13.666,  -9.202,   1.500
N, 248,  15.388,  -5.894,   1.500
N, 249,  15.389,  -7.549,   1.500
N, 250,  15.390,  -9.203,   1.500
N, 251,  16.545,  -4.646,   1.500
N, 252,  16.546,  -6.925,   1.500
N, 253,  16.546,  -9.205,   1.500
N, 254,  17.234,  -4.075,   1.500
N, 255,  17.235,  -6.640,   1.500
N, 256,  17.235,  -9.205,   1.500
N, 257,  18.286,  -3.861,   1.500
N, 258,  18.286,  -6.534,   1.500
N, 259,  18.286,  -9.206,   1.500
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N, 261,  18.732,  -6.534,   1.500
N, 262,  18.732,  -9.207,   1.500
N, 263,  19.179,  -3.861,   1.500
N, 264,  19.179,  -6.534,   1.500
N, 265,  19.179,  -9.207,   1.500
N, 266,  19.625,  -3.861,   1.500
N, 267,  19.625,  -6.534,   1.500
N, 268,  19.625,  -9.208,   1.500
N, 269,  21.500,  -3.862,   1.500
N, 270,  21.500,  -6.536,   1.500
N, 271,  21.500,  -9.210,   1.500
N, 272,   1.625,    .000,   1.500
N, 273,  19.625,    .000,   1.500
N, 274,   5.219,   3.609,    .750
N, 275,    .500,   -.588,   2.200
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .500
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
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TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E,  101,  102,  107,  106
EGEN,    4,     1,   77,   77,     1
EGEN,   19,     5,   77,   80,     1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 306,  31
EGEN,   8,   5, 153, 153,   1
EGEN,   5,   1, 153, 160,   1
E, 406, 131
EGEN,   8,   5, 193, 193,   1
EGEN,   5,   1, 193, 200,   1
/COM *****ATTACHMENT QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R,  4,  .100
REAL,  4
E,   37,   43,  202,  201
E,   43,   49,  203,  202
E,   49,   54,  204,  203
E,   54,   59,  205,  204
E,   59,   64,  206,  205
E,   64,   63,  207,  206
E,   63,   62,  208,  207
E,   62,   61,  209,  208
E,   61,   56,  210,  209
E,   56,   51,  211,  210
R,  5,  .200
REAL,  5
E,  103,  108,  213,  212
E,  212,  213,  215,  214
E,  214,  215,  217,  216
E,  108,  113,  218,  213
E,  213,  218,  219,  215
E,  215,  219,  220,  217
E,  113,  118,  221,  218
E,  218,  221,  222,  219
E,  219,  222,  223,  220
E,  118,  123,  224,  221
E,  221,  224,  225,  222
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E, 222, 225, 226, 223
E, 123, 128, 227, 224
E, 224, 227, 228, 225
E, 225, 228, 229, 226
E, 128, 133, 230, 227
E, 227, 230, 231, 228
E, 228, 231, 232, 229
E, 133, 138, 233, 230
E, 230, 233, 234, 231
E, 231, 234, 235, 232
E, 138, 143, 236, 233
E, 233, 236, 237, 234
E, 234, 237, 238, 235
E, 143, 148, 239, 236
E, 236, 239, 240, 237
E, 237, 240, 241, 238
E, 148, 153, 242, 239
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E, 242, 245, 246, 243
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E, 158, 163, 248, 245
E, 245, 248, 249, 246
E, 246, 249, 250, 247
E, 163, 168, 251, 248
E, 248, 251, 252, 249
E, 249, 252, 253, 250
E, 168, 173, 254, 251
E, 251, 254, 255, 252
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E, 173, 178, 257, 254
E, 254, 257, 258, 255
E, 255, 258, 259, 256
E, 178, 183, 260, 257
E, 257, 260, 261, 258
E, 258, 261, 262, 259
E, 183, 188, 263, 260
E, 260, 263, 264, 261
E, 261, 264, 265, 262
E, 188, 193, 266, 263
E, 263, 266, 267, 264
E, 264, 267, 268, 265
E, 193, 198, 269, 266
E, 266, 269, 270, 267
E, 267, 270, 271, 268
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/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   6,  100.0000,  999.0000,  999.0000,     1.0000,     1.0000,,,  999.0000
REAL,   6
E ,  201,  202
E ,  202,  203
E ,  203,  204
E ,  204,  205
E ,  205,  206
E ,  206,  207
E ,  207,  208
E ,  208,  209
E ,  209,  210
E ,  210,  211
E ,  216,  217
E ,  217,  220
E ,  220,  223
E ,  223,  226
E ,  226,  229
E ,  229,  232
E ,  232,  235
E ,  235,  238
E ,  238,  241
E ,  241,  244
E ,  244,  247
E ,  247,  250
E ,  250,  253
E ,  253,  256
E ,  256,  259
E ,  259,  262
E ,  262,  265
E ,  265,  268
E ,  268,  271
R,   7,    1.7671,     .2485,     .2485,     1.5000,     1.5000,,,     .4970
REAL,   7
E ,    8,  272
E ,  272,  108
E ,   93,  273
E ,  273,  193
R,   8,  100.0000,  999.0000,  999.0000,     1.0000,     1.0000,,,  999.0000
REAL,   8
E ,  201,  274
E ,  216,  275
LOADS
CSYS, 0
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ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  306, ALL, 0.0,, 341,  5
D,  307, ALL, 0.0,, 342,  5
D,  308, ALL, 0.0,, 343,  5
D,  309, ALL, 0.0,, 344,  5
D,  310, ALL, 0.0,, 345,  5
D,  406, ALL, 0.0,, 441,  5
D,  407, ALL, 0.0,, 442,  5
D,  408, ALL, 0.0,, 443,  5
D,  409, ALL, 0.0,, 444,  5
D,  410, ALL, 0.0,, 445,  5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  274,FX,       1.000
F,  274,FY,       2.000
F,  274,FZ,       3.000
F,  274,MX,       4.000
F,  274,MY,       5.000
F,  274,MZ,       6.000
F,  275,FX,       7.000
F,  275,FY,       8.000
F,  275,FZ,       9.000
F,  275,MX,      10.000
F,  275,MY,      11.000
F,  275,MZ,      12.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 6

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/PREP7
/TITLE TEST6
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  11.000,   0.0,   0.0
LOCAL, 12, 1,   5.822,   2.500, 0.0
LOCAL, 13, 1,  16.292,   2.250, 0.0
LOCAL, 14, 1,   5.371,  -3.250, 0.0
LOCAL, 15, 1,  16.766,  -3.000, 0.0
CSYS, 0
N,    1,     .000,    1.125,     .000
N,    2,     .000,    1.125,     .625
N,    3,     .000,    1.125,    1.250
N,    4,     .000,    1.125,    2.000
N,    5,     .000,    1.125,    2.750
N,    6,     .000,    1.125,    3.375
N,    7,     .000,    1.125,    4.000
N,    8,    1.000,    1.125,     .000
N,    9,    1.000,    1.125,     .625
N,   10,    1.000,    1.125,    1.250
N,   11,    1.000,    1.125,    2.000
N,   12,    1.000,    1.125,    2.750
N,   13,    1.000,    1.125,    3.375
N,   14,    1.000,    1.125,    4.000
N,   15,    2.000,    1.125,     .000
N,   16,    2.000,    1.125,     .625
N,   17,    2.000,    1.125,    1.250
N,   18,    2.000,    1.125,    2.000
N,   19,    2.000,    1.125,    2.750
N,   20,    2.000,    1.125,    3.375
N,   21,    2.000,    1.125,    4.000
N,   22,    2.750,    1.125,     .000
N,   23,    2.750,    1.125,     .625
N,   24,    2.750,    1.125,    1.250
N,   25,    2.750,    1.125,    2.000
N,   26,    2.750,    1.125,    2.750
N,   27,    2.750,    1.125,    3.375
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N,	28,	2.750,	1.125,	4.000
N,	29,	3.500,	1.125,	.000
N,	30,	3.500,	1.125,	.625
N,	31,	3.500,	1.125,	1.250
N,	32,	3.500,	1.125,	2.000
N,	33,	3.500,	1.125,	2.750
N,	34,	3.500,	1.125,	3.375
N,	35,	3.500,	1.125,	4.000
N,	36,	4.500,	1.125,	.000
N,	37,	4.500,	1.125,	.625
N,	38,	4.500,	1.125,	1.250
N,	39,	4.500,	1.125,	2.000
N,	40,	4.500,	1.125,	2.750
N,	41,	4.500,	1.125,	3.375
N,	42,	4.500,	1.125,	4.000
N,	43,	5.161,	1.125,	.000
N,	44,	5.161,	1.125,	.625
N,	45,	5.161,	1.125,	1.250
N,	46,	5.161,	1.125,	2.000
N,	47,	5.161,	1.125,	2.750
N,	48,	5.161,	1.125,	3.375
N,	49,	5.161,	1.125,	4.000
N,	50,	5.822,	1.125,	.000
N,	51,	5.822,	1.125,	.625
N,	52,	5.822,	1.125,	1.250
N,	53,	5.822,	1.125,	2.000
N,	54,	5.822,	1.125,	2.750
N,	55,	5.822,	1.125,	3.375
N,	56,	5.822,	1.125,	4.000
N,	176,	16.292,	.875,	.000
N,	177,	16.292,	.875,	.625
N,	178,	16.292,	.875,	1.250
N,	179,	16.292,	.875,	2.000
N,	180,	16.292,	.875,	2.750
N,	181,	16.292,	.875,	3.375
N,	182,	16.292,	.875,	4.000
N,	183,	16.861,	.875,	.000
N,	184,	16.861,	.875,	.625
N,	185,	16.861,	.875,	1.250
N,	186,	16.861,	.875,	2.000
N,	187,	16.861,	.875,	2.750
N,	188,	16.861,	.875,	3.375
N,	189,	16.861,	.875,	4.000
N,	190,	17.431,	.875,	.000
N,	191,	17.431,	.875,	.625
N,	192,	17.431,	.875,	1.250

N,	193,	17.431,	.875,	2.000
N,	194,	17.431,	.875,	2.750
N,	195,	17.431,	.875,	3.375
N,	196,	17.431,	.875,	4.000
N,	197,	18.000,	.875,	.000
N,	198,	18.000,	.875,	.625
N,	199,	18.000,	.875,	1.250
N,	200,	18.000,	.875,	2.000
N,	201,	18.000,	.875,	2.750
N,	202,	18.000,	.875,	3.375
N,	203,	18.000,	.875,	4.000
N,	204,	18.750,	.875,	.000
N,	205,	18.750,	.875,	.625
N,	206,	18.750,	.875,	1.250
N,	207,	18.750,	.875,	2.000
N,	208,	18.750,	.875,	2.750
N,	209,	18.750,	.875,	3.375
N,	210,	18.750,	.875,	4.000
N,	211,	20.000,	.875,	.000
N,	212,	20.000,	.875,	.625
N,	213,	20.000,	.875,	1.250
N,	214,	20.000,	.875,	2.000
N,	215,	20.000,	.875,	2.750
N,	216,	20.000,	.875,	3.375
N,	217,	20.000,	.875,	4.000
N,	218,	.000,	-1.250,	.000
N,	219,	.000,	-1.250,	.625
N,	220,	.000,	-1.250,	1.250
N,	221,	.000,	-1.250,	2.000
N,	222,	.000,	-1.250,	2.750
N,	223,	.000,	-1.250,	3.375
N,	224,	.000,	-1.250,	4.000
N,	225,	1.000,	-1.250,	.000
N,	226,	1.000,	-1.250,	.625
N,	227,	1.000,	-1.250,	1.250
N,	228,	1.000,	-1.250,	2.000
N,	229,	1.000,	-1.250,	2.750
N,	230,	1.000,	-1.250,	3.375
N,	231,	1.000,	-1.250,	4.000
N,	232,	2.000,	-1.250,	.000
N,	233,	2.000,	-1.250,	.625
N,	234,	2.000,	-1.250,	1.250
N,	235,	2.000,	-1.250,	2.000
N,	236,	2.000,	-1.250,	2.750
N,	237,	2.000,	-1.250,	3.375
N,	238,	2.000,	-1.250,	4.000

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N,  239,   2.500,  -1.250,    .000
N,  240,   2.500,  -1.250,    .625
N,  241,   2.500,  -1.250,   1.250
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N,   70,   1.375, -47.181,   4.000
CSYS, 13
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N,  285,   2.000,   50.000,    2.750
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/COM *****GAP FOUNDATION NODES*****
CSYS, 11
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N, 442,    3.341,    3.610,    1.250
N, 443,    2.520,    3.227,    1.250
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N, 485, 5.234, -4.767, 2.750
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/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,   .750
REAL,  1
E,   1,   2,   9,   8
EGEN,   6,   1,   1,   1,   1
EGEN,  30,   7,   1,   6,   1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,  1.000
REAL,  2
E, 218, 219, 226, 225
EGEN,   6,   1, 181, 181,   1
EGEN,  30,   7, 181, 186,   1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R, 3, 10.0
REAL,  3
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E, 606,  71
EGEN,  13,   7, 361, 361,   1
EGEN,   7,   1, 361, 373,   1
E, 823, 288
EGEN,  13,   7, 452, 452,   1
EGEN,   7,   1, 452, 464,   1
/COM *****ATTACHMENT QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R,  4,  .500
REAL,  4
E,   87,   80,  436,  435
E,   80,   73,  437,  436
E,   73,   66,  438,  437
E,   66,   59,  439,  438
E,   59,   52,  440,  439
E,   52,   45,  441,  440
E,   45,   38,  442,  441
E,   38,   31,  443,  442
E,   89,   82,  445,  444
E,   82,   75,  446,  445
E,   75,   68,  447,  446
E,   68,   61,  448,  447
E,   61,   54,  449,  448
E,   54,   47,  450,  449
E,   47,   40,  451,  450
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E,  143,  150,  454,  453
E,  150,  157,  455,  454
E,  157,  164,  456,  455
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E,  171,  178,  458,  457
E,  178,  185,  459,  458
E,  185,  192,  460,  459
E,  192,  199,  461,  460
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E,  145,  152,  464,  463
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E,  166,  173,  467,  466
E,  173,  180,  468,  467
E,  180,  187,  469,  468
E,  187,  194,  470,  469
E,  194,  201,  471,  470
E,  201,  208,  472,  471
E,  304,  297,  474,  473
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E, 290, 283, 476, 475
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E, 369, 376, 515, 512
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E, 404, 411, 525, 523
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E, 411, 418, 527, 525
E, 525, 527, 528, 526
E, 418, 425, 529, 527
E, 527, 529, 530, 528
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  5, 100.0000, 999.0000, 999.0000,   1.0000,   1.0000,,, 999.0000
REAL,  5
E ,  108,  115
E ,  115,  122
E ,  122,  123
E ,  123,  124
E ,  124,  117
E ,  117,  110
E ,  110,  109
E ,  109,  108
R,  6,    .4418,    .0155,    .0155,    .7500,    .7500,,,    .0311
REAL,  6
E ,   17,  531
E ,  531,  234
E ,   19,  532
E ,  532,  236
R,  7,    .7854,    .0491,    .0491,   1.0000,   1.0000,,,    .0982
REAL,  7
E ,   39,  533
E ,  533,  256
E ,  200,  534
E ,  534,  417
R,  8, 100.0000, 999.0000, 999.0000,   1.0000,   1.0000,,, 999.0000
REAL,  8
E ,  108,  535
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  606, ALL, 0.0,, 690,   7
D,  607, ALL, 0.0,, 691,   7
D,  608, ALL, 0.0,, 692,   7
D,  609, ALL, 0.0,, 693,   7
D,  610, ALL, 0.0,, 694,   7
D,  611, ALL, 0.0,, 695,   7
D,  612, ALL, 0.0,, 696,   7
D,  823, ALL, 0.0,, 907,   7
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D,  824, ALL, 0.0,, 908,   7
D,  825, ALL, 0.0,, 909,   7
D,  826, ALL, 0.0,, 910,   7
D,  827, ALL, 0.0,, 911,   7
D,  828, ALL, 0.0,, 912,   7
D,  829, ALL, 0.0,, 913,   7
/COM *****USER RESTRAINT DEFINITION*****
D,   85,  UZ, 0.0
D,   91,  UZ, 0.0
D,  141,  UZ, 0.0
D,  147,  UZ, 0.0
D,  302,  UZ, 0.0
D,  308,  UZ, 0.0
D,  358,  UZ, 0.0
D,  364,  UZ, 0.0
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  535,FX,      1.000
F,  535,FY,      2.000
F,  535,FZ,      3.000
F,  535,MX,      4.000
F,  535,MY,      5.000
F,  535,MZ,      6.000
F,  531,FX,      7.000
F,  531,FY,      8.000
F,  531,FZ,      9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 7

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/PREP7
/TITLE TEST7
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,    0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,     .813,     .000
N,    2,     .000,     .813,     .750
N,    3,     .000,     .813,    1.500
N,    4,     .000,     .813,    2.250
N,    5,     .000,     .813,    3.000
N,    6,    1.625,     .813,     .000
N,    7,    1.625,     .813,     .750
N,    8,    1.625,     .813,    1.500
N,    9,    1.625,     .813,    2.250
N,   10,    1.625,     .813,    3.000
N,   11,    2.187,     .813,     .000
N,   12,    2.187,     .813,     .750
N,   13,    2.187,     .813,    1.500
N,   14,    2.187,     .813,    2.250
N,   15,    2.187,     .813,    3.000
N,   16,    2.749,     .813,     .000
N,   17,    2.749,     .813,     .750
N,   18,    2.749,     .813,    1.500
N,   19,    2.749,     .813,    2.250
N,   20,    2.749,     .813,    3.000
N,   21,    3.311,     .813,     .000
N,   22,    3.311,     .813,     .750
N,   23,    3.311,     .813,    1.500
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N,   77,   18.060,     .438,     .750
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N, 112,   2.187,  -.813,   .750
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N, 123,   3.311,  -.813,  1.500
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CSYS, 12
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N,   27,   1.750,  -54.654,     .750
N,   28,   1.750,  -54.654,    1.500
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N,   72,   1.750, -126.802,     .750
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N,   75,   1.750, -126.802,    3.000
CSYS, 14
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N,  130,   1.750,   54.654,    3.000
CSYS, 15
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N,  173,   1.750,  126.802,    1.500
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N,  175,   1.750,  126.802,    3.000
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CSYS, 12
NGEN ,   2,  200,   26,   30,    1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,   2,  200,   31,   70,    1,  .7500,  .0000,  .0000
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NGEN ,    2, 200,   71,   75,    1, -.7500,  .0000,  .0000
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NGEN ,    2, 200,   76,  100,    1,  .0000,  .7500,  .0000
CSYS,  0
NGEN ,    2, 200,  101,  125,    1,  .0000, -.7500,  .0000
CSYS, 14
NGEN ,    2, 200,  126,  130,    1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,    2, 200,  131,  170,    1,  .7500,  .0000,  .0000
CSYS, 15
NGEN ,    2, 200,  171,  175,    1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2, 200,  176,  200,    1,  .0000, -.7500,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2, 402,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,   34,   69,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2, 402,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  401,    1.625,     .000,    1.500
N,  402,   19.625,     .000,    1.500
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,    1,    2,    7,    6,  201,  202,  207,  206
EGEN,   4,    1,    1,    1,    1
EGEN,  19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E,  101,  102,  107,  106,  301,  302,  307,  306
EGEN,   4,    1,   77,   77,    1
EGEN,  19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  1, 10.0
REAL,  1
E, 433,  31
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EGEN,   8,   5, 153, 153,   1
EGEN,   5,   1, 153, 160,   1
E, 533, 131
EGEN,   8,   5, 193, 193,   1
EGEN,   5,   1, 193, 200,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  2,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,  2
E ,    8,  401
E ,  401,  108
E ,   93,  402
E ,  402,  193
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  433, ALL, 0.0,, 468,   5
D,  434, ALL, 0.0,, 469,   5
D,  435, ALL, 0.0,, 470,   5
D,  436, ALL, 0.0,, 471,   5
D,  437, ALL, 0.0,, 472,   5
D,  533, ALL, 0.0,, 568,   5
D,  534, ALL, 0.0,, 569,   5
D,  535, ALL, 0.0,, 570,   5
D,  536, ALL, 0.0,, 571,   5
D,  537, ALL, 0.0,, 572,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  401,FX,      -9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 8

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/PREP7
/TITLE TEST8
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     29000.000
NUXY, 1,  .200
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,     .813,     .000
N,    2,     .000,     .813,     .500
N,    3,     .000,     .813,    1.000
N,    4,     .000,     .813,    1.500
N,    5,     .000,     .813,    2.000
N,    6,     .000,     .813,    2.500
N,    7,     .000,     .813,    3.000
N,    8,    1.625,     .813,     .000
N,    9,    1.625,     .813,     .500
N,   10,    1.625,     .813,    1.000
N,   11,    1.625,     .813,    1.500
N,   12,    1.625,     .813,    2.000
N,   13,    1.625,     .813,    2.500
N,   14,    1.625,     .813,    3.000
N,   15,    2.046,     .813,     .000
N,   16,    2.046,     .813,     .500
N,   17,    2.046,     .813,    1.000
N,   18,    2.046,     .813,    1.500
N,   19,    2.046,     .813,    2.000
N,   20,    2.046,     .813,    2.500
N,   21,    2.046,     .813,    3.000
N,   22,    2.468,     .813,     .000
N,   23,    2.468,     .813,     .500
N,   24,    2.468,     .813,    1.000
N,   25,    2.468,     .813,    1.500
N,   26,    2.468,     .813,    2.000
N,   27,    2.468,     .813,    2.500
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N,	28,	2.468,	.813,	3.000
N,	29,	2.889,	.813,	.000
N,	30,	2.889,	.813,	.500
N,	31,	2.889,	.813,	1.000
N,	32,	2.889,	.813,	1.500
N,	33,	2.889,	.813,	2.000
N,	34,	2.889,	.813,	2.500
N,	35,	2.889,	.813,	3.000
N,	36,	3.311,	.813,	.000
N,	37,	3.311,	.813,	.500
N,	38,	3.311,	.813,	1.000
N,	39,	3.311,	.813,	1.500
N,	40,	3.311,	.813,	2.000
N,	41,	3.311,	.813,	2.500
N,	42,	3.311,	.813,	3.000
N,	141,	18.060,	.438,	.000
N,	142,	18.060,	.438,	.500
N,	143,	18.060,	.438,	1.000
N,	144,	18.060,	.438,	1.500
N,	145,	18.060,	.438,	2.000
N,	146,	18.060,	.438,	2.500
N,	147,	18.060,	.438,	3.000
N,	148,	18.373,	.438,	.000
N,	149,	18.373,	.438,	.500
N,	150,	18.373,	.438,	1.000
N,	151,	18.373,	.438,	1.500
N,	152,	18.373,	.438,	2.000
N,	153,	18.373,	.438,	2.500
N,	154,	18.373,	.438,	3.000
N,	155,	18.686,	.438,	.000
N,	156,	18.686,	.438,	.500
N,	157,	18.686,	.438,	1.000
N,	158,	18.686,	.438,	1.500
N,	159,	18.686,	.438,	2.000
N,	160,	18.686,	.438,	2.500
N,	161,	18.686,	.438,	3.000
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N,	163,	18.999,	.438,	.500
N,	164,	18.999,	.438,	1.000
N,	165,	18.999,	.438,	1.500
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N,	167,	18.999,	.438,	2.500
N,	168,	18.999,	.438,	3.000
N,	169,	19.312,	.438,	.000
N,	170,	19.312,	.438,	.500
N,	171,	19.312,	.438,	1.000

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N,  172,  19.312,    .438,   1.500
N,  173,  19.312,    .438,   2.000
N,  174,  19.312,    .438,   2.500
N,  175,  19.312,    .438,   3.000
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N,  177,  19.625,    .438,    .500
N,  178,  19.625,    .438,   1.000
N,  179,  19.625,    .438,   1.500
N,  180,  19.625,    .438,   2.000
N,  181,  19.625,    .438,   2.500
N,  182,  19.625,    .438,   3.000
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N,  184,  21.500,    .438,    .500
N,  185,  21.500,    .438,   1.000
N,  186,  21.500,    .438,   1.500
N,  187,  21.500,    .438,   2.000
N,  188,  21.500,    .438,   2.500
N,  189,  21.500,    .438,   3.000
N,  190,    .000,   -.813,    .000
N,  191,    .000,   -.813,    .750
N,  192,    .000,   -.813,   1.500
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N,  194,    .000,   -.813,   3.000
N,  195,    .813,   -.813,    .000
N,  196,    .813,   -.813,    .750
N,  197,    .813,   -.813,   1.500
N,  198,    .813,   -.813,   2.250
N,  199,    .813,   -.813,   3.000
N,  200,   1.625,   -.813,    .000
N,  201,   1.625,   -.813,    .750
N,  202,   1.625,   -.813,   1.500
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N,  204,   1.625,   -.813,   3.000
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N,  206,   2.187,   -.813,    .750
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N,  209,   2.187,   -.813,   3.000
N,  210,   2.749,   -.813,    .000
N,  211,   2.749,   -.813,    .750
N,  212,   2.749,   -.813,   1.500
N,  213,   2.749,   -.813,   2.250
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N,  215,   3.311,   -.813,    .000
N,  216,   3.311,   -.813,    .750
N,  217,   3.311,   -.813,   1.500
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N, 219,   3.311,   -.813,   3.000
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N, 256,  18.060,   -.438,    .750
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N, 258,  18.060,   -.438,   2.250
N, 259,  18.060,   -.438,   3.000
N, 260,  18.842,   -.438,    .000
N, 261,  18.842,   -.438,    .750
N, 262,  18.842,   -.438,   1.500
N, 263,  18.842,   -.438,   2.250
N, 264,  18.842,   -.438,   3.000
N, 265,  19.625,   -.438,    .000
N, 266,  19.625,   -.438,    .750
N, 267,  19.625,   -.438,   1.500
N, 268,  19.625,   -.438,   2.250
N, 269,  19.625,   -.438,   3.000
N, 270,  21.500,   -.438,    .000
N, 271,  21.500,   -.438,    .750
N, 272,  21.500,   -.438,   1.500
N, 273,  21.500,   -.438,   2.250
N, 274,  21.500,   -.438,   3.000
CSYS, 11
N,   50,   6.000, 160.692,    .000
N,   51,   6.000, 160.692,    .500
N,   52,   6.000, 160.692,   1.000
N,   53,   6.000, 160.692,   1.500
N,   54,   6.000, 160.692,   2.000
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N,   58,   6.000, 146.262,    .500
N,   59,   6.000, 146.262,   1.000
N,   60,   6.000, 146.262,   1.500
N,   61,   6.000, 146.262,   2.000
N,   62,   6.000, 146.262,   2.500
N,   63,   6.000, 146.262,   3.000
N,   64,   6.000, 131.833,    .000
N,   65,   6.000, 131.833,    .500
N,   66,   6.000, 131.833,   1.000
N,   67,   6.000, 131.833,   1.500
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N,   70,   6.000, 131.833,   3.000
N,   71,   6.000, 117.403,    .000
N,   72,   6.000, 117.403,    .500
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N,	74,	6.000,	117.403,	1.500
N,	75,	6.000,	117.403,	2.000
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N,	77,	6.000,	117.403,	3.000
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N,	79,	6.000,	102.973,	.500
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N,	81,	6.000,	102.973,	1.500
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N,	100,	6.000,	59.684,	.500
N,	101,	6.000,	59.684,	1.000
N,	102,	6.000,	59.684,	1.500
N,	103,	6.000,	59.684,	2.000
N,	104,	6.000,	59.684,	2.500
N,	105,	6.000,	59.684,	3.000
N,	106,	6.000,	45.254,	.000
N,	107,	6.000,	45.254,	.500
N,	108,	6.000,	45.254,	1.000
N,	109,	6.000,	45.254,	1.500
N,	110,	6.000,	45.254,	2.000
N,	111,	6.000,	45.254,	2.500
N,	112,	6.000,	45.254,	3.000
N,	113,	6.000,	30.825,	.000
N,	114,	6.000,	30.825,	.500
N,	115,	6.000,	30.825,	1.000
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N,	117,	6.000,	30.825,	2.000
N,	118,	6.000,	30.825,	2.500

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N,  119,   6.000,   30.825,   3.000
N,  120,   6.000,   16.395,    .000
N,  121,   6.000,   16.395,    .500
N,  122,   6.000,   16.395,   1.000
N,  123,   6.000,   16.395,   1.500
N,  124,   6.000,   16.395,   2.000
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N,  126,   6.000,   16.395,   3.000
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N,  231,   6.000, -102.973,    .750
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N,  243,   6.000,  -45.254,   2.250
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N,  245,   6.000,  -16.395,    .000
N,  246,   6.000,  -16.395,    .750
N,  247,   6.000,  -16.395,   1.500
N,  248,   6.000,  -16.395,   2.250
N,  249,   6.000,  -16.395,   3.000
CSYS, 12
N,   43,   1.750,  -54.654,    .000
N,   44,   1.750,  -54.654,    .500
N,   45,   1.750,  -54.654,   1.000
N,   46,   1.750,  -54.654,   1.500
N,   47,   1.750,  -54.654,   2.000
N,   48,   1.750,  -54.654,   2.500
N,   49,   1.750,  -54.654,   3.000
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CSYS, 13
N,  127,    1.750, -139.070,     .000
N,  128,    1.750, -139.070,     .500
N,  129,    1.750, -139.070,    1.000
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N,  137,    1.750, -114.535,    1.500
N,  138,    1.750, -114.535,    2.000
N,  139,    1.750, -114.535,    2.500
N,  140,    1.750, -114.535,    3.000
CSYS, 14
CSYS, 15
N,  250,    1.750,  126.802,     .000
N,  251,    1.750,  126.802,     .750
N,  252,    1.750,  126.802,    1.500
N,  253,    1.750,  126.802,    2.250
N,  254,    1.750,  126.802,    3.000
CSYS,  0
NGEN ,    3,  274,    1,   42,    1,  .0000,  .3750,  .0000
CSYS, 12
NGEN ,    3,  274,   43,   49,    1, -.3750,  .0000,  .0000
CSYS, 11
NGEN ,    3,  274,   50,  126,    1,  .3750,  .0000,  .0000
CSYS, 13
NGEN ,    3,  274,  127,  140,    1, -.3750,  .0000,  .0000
CSYS,  0
NGEN ,    3,  274,  141,  189,    1,  .0000,  .3750,  .0000
CSYS,  0
NGEN ,    2,  274,  190,  219,    1,  .0000, -.7500,  .0000
CSYS, 14
NGEN ,    2,  274,  220,  219,    1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,    2,  274,  220,  249,    1,  .7500,  .0000,  .0000
CSYS, 15
NGEN ,    2,  274,  250,  280,    1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2,  274,  281,  274,    1,  .0000, -.7500,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  824,   50,  120,    7, -.1000,  .0000,  .0000
NGEN ,    2,  824,   51,  121,    7, -.1000,  .0000,  .0000
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NGEN ,   2, 824,  52, 122,   7, -.1000,  .0000,  .0000
NGEN ,   2, 824,  53, 123,   7, -.1000,  .0000,  .0000
NGEN ,   2, 824,  54, 124,   7, -.1000,  .0000,  .0000
NGEN ,   2, 824,  55, 125,   7, -.1000,  .0000,  .0000
NGEN ,   2, 824,  56, 126,   7, -.1000,  .0000,  .0000
NGEN ,   2, 824, 220, 245,   5, -.1000,  .0000,  .0000
NGEN ,   2, 824, 221, 246,   5, -.1000,  .0000,  .0000
NGEN ,   2, 824, 222, 247,   5, -.1000,  .0000,  .0000
NGEN ,   2, 824, 223, 248,   5, -.1000,  .0000,  .0000
NGEN ,   2, 824, 224, 249,   5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  823,    1.625,     .000,    1.500
N,  824,   19.625,     .000,    1.500
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,    1,    2,    9,    8,  275,  276,  283,  282
EGEN,    6,    1,    1,    1,    1
EGEN,   26,    7,    1,    6,    1
EGEN,    2,  274,    1,  156,    1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E,  190,  191,  196,  195,  464,  465,  470,  469
EGEN,    4,    1,  313,  313,    1
EGEN,   16,    5,  313,  316,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  1, 10.0
REAL,  1
E, 874,  50
EGEN,  11,   7, 377, 377,   1
EGEN,   7,   1, 377, 387,   1
E,1044, 220
EGEN,   6,   5, 454, 454,   1
EGEN,   5,   1, 454, 459,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  2,    1.7671,    .2485,    .2485,    1.5000,    1.5000,,,     .4970
REAL,  2
E ,   11,  823
E ,  823,  202
E ,  179,  824
E ,  824,  267
LOADS
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CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  874, ALL, 0.0,, 944,   7
D,  875, ALL, 0.0,, 945,   7
D,  876, ALL, 0.0,, 946,   7
D,  877, ALL, 0.0,, 947,   7
D,  878, ALL, 0.0,, 948,   7
D,  879, ALL, 0.0,, 949,   7
D,  880, ALL, 0.0,, 950,   7
D, 1044, ALL, 0.0,,1069,   5
D, 1045, ALL, 0.0,,1070,   5
D, 1046, ALL, 0.0,,1071,   5
D, 1047, ALL, 0.0,,1072,   5
D, 1048, ALL, 0.0,,1073,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  823,FX,       -9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

Validation Problem No. 9

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/PREP7
/TITLE TEST9
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,      29000.000
NUXY, 1,  .330
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,     .813,     .000
N,    2,     .000,     .813,     .750
N,    3,     .000,     .813,    1.500
N,    4,     .000,     .813,    2.250
N,    5,     .000,     .813,    3.000
N,    6,     .813,     .813,     .000
N,    7,     .813,     .813,     .750
N,    8,     .813,     .813,    1.500
N,    9,     .813,     .813,    2.250
N,   10,     .813,     .813,    3.000
N,   11,    1.625,     .813,     .000
N,   12,    1.625,     .813,     .750
N,   13,    1.625,     .813,    1.500
N,   14,    1.625,     .813,    2.250
N,   15,    1.625,     .813,    3.000
N,   16,    2.187,     .813,     .000
N,   17,    2.187,     .813,     .750
N,   18,    2.187,     .813,    1.500
N,   19,    2.187,     .813,    2.250
N,   20,    2.187,     .813,    3.000
N,   21,    2.749,     .813,     .000
N,   22,    2.749,     .813,     .750
N,   23,    2.749,     .813,    1.500
N,   24,    2.749,     .813,    2.250
N,   25,    2.749,     .813,    3.000
N,   26,    3.311,     .813,     .000
N,   27,    3.311,     .813,     .750
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N, 108,  18.842,   .438,  1.500
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N, 110,  18.842,   .438,  3.000
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N, 112,  19.625,   .438,   .500
N, 113,  19.625,   .438,  1.500
N, 114,  19.625,   .438,  2.500
N, 115,  19.625,   .438,  3.000
N, 116,  21.500,   .438,   .000
N, 117,  21.500,   .438,   .500
N, 118,  21.500,   .438,  1.500
N, 119,  21.500,   .438,  2.500
N, 120,  21.500,   .438,  3.000
N, 121,    .000,  -.813,   .000
N, 122,    .000,  -.813,   .625
N, 123,    .000,  -.813,  1.500
N, 124,    .000,  -.813,  2.375
N, 125,    .000,  -.813,  3.000
N, 126,   1.625,  -.813,   .000
N, 127,   1.625,  -.813,   .625
N, 128,   1.625,  -.813,  1.500
N, 129,   1.625,  -.813,  2.375
N, 130,   1.625,  -.813,  3.000
N, 131,   2.468,  -.813,   .000
N, 132,   2.468,  -.813,   .625
N, 133,   2.468,  -.813,  1.500
N, 134,   2.468,  -.813,  2.375
N, 135,   2.468,  -.813,  3.000
N, 136,   3.311,  -.813,   .000
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N, 140,   3.311,  -.813,  3.000
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N, 222,  18.060,  -.438,  1.000
N, 223,  18.060,  -.438,  1.500
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N,  227,   18.842,    -.438,    1.000
N,  228,   18.842,    -.438,    1.500
N,  229,   18.842,    -.438,    2.000
N,  230,   18.842,    -.438,    3.000
N,  231,   19.625,    -.438,     .000
N,  232,   19.625,    -.438,    1.000
N,  233,   19.625,    -.438,    1.500
N,  234,   19.625,    -.438,    2.000
N,  235,   19.625,    -.438,    3.000
N,  236,   20.563,    -.438,     .000
N,  237,   20.563,    -.438,    1.000
N,  238,   20.563,    -.438,    1.500
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N,  240,   20.563,    -.438,    3.000
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CSYS, 11
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N,    37,    6.000,  160.692,     .750
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N,    44,    6.000,  145.000,    2.250
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N,    49,    6.000,  135.000,    2.250
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N, 157,  6.000, -145.000,   .625
N, 158,  6.000, -145.000,  1.500
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N, 160,  6.000, -145.000,  3.000
N, 161,  6.000, -135.000,   .000
N, 162,  6.000, -135.000,   .625
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N, 164,  6.000, -135.000,  2.375
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N,  194,   6.000,  -64.167,   2.094
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N,  210,   6.000,  -40.000,   3.000
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N,  215,    6.000,  -16.395,    3.000
CSYS, 12
N,   31,    1.750,  -54.654,     .000
N,   32,    1.750,  -54.654,     .750
N,   33,    1.750,  -54.654,    1.500
N,   34,    1.750,  -54.654,    2.250
N,   35,    1.750,  -54.654,    3.000
CSYS, 13
N,   91,    1.750, -139.070,     .000
N,   92,    1.750, -139.070,     .500
N,   93,    1.750, -139.070,    1.500
N,   94,    1.750, -139.070,    2.500
N,   95,    1.750, -139.070,    3.000
N,   96,    1.750, -114.535,     .000
N,   97,    1.750, -114.535,     .500
N,   98,    1.750, -114.535,    1.500
N,   99,    1.750, -114.535,    2.500
N,  100,    1.750, -114.535,    3.000
CSYS, 14
N,  141,    1.750,   66.436,     .000
N,  142,    1.750,   66.436,     .625
N,  143,    1.750,   66.436,    1.500
N,  144,    1.750,   66.436,    2.375
N,  145,    1.750,   66.436,    3.000
N,  146,    1.750,   42.872,     .000
N,  147,    1.750,   42.872,     .625
N,  148,    1.750,   42.872,    1.500
N,  149,    1.750,   42.872,    2.375
N,  150,    1.750,   42.872,    3.000
CSYS, 15
N,  216,    1.750,  126.802,     .000
N,  217,    1.750,  126.802,    1.000
N,  218,    1.750,  126.802,    1.500
N,  219,    1.750,  126.802,    2.000
N,  220,    1.750,  126.802,    3.000
CSYS,  0
NGEN ,    2,  245,    1,   30,    1,  .0000,  .7500,  .0000
CSYS, 12
NGEN ,    2,  245,   31,   35,    1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,    2,  245,   36,   90,    1,  .7500,  .0000,  .0000
CSYS, 13
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NGEN ,   2, 245,  91, 100,   1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,   2, 245, 101, 120,   1,  .0000,  .7500,  .0000
CSYS,  0
NGEN ,   3, 245, 121, 140,   1,  .0000, -.3750,  .0000
CSYS, 14
NGEN ,   3, 245, 141, 150,   1, -.3750,  .0000,  .0000
CSYS, 11
NGEN ,   3, 245, 151, 215,   1,  .3750,  .0000,  .0000
CSYS, 15
NGEN ,   3, 245, 216, 220,   1, -.3750,  .0000,  .0000
CSYS,  0
NGEN ,   3, 245, 221, 245,   1,  .0000, -.3750,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,   2, 779,  36,  86,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779,  37,  87,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779,  38,  88,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779,  39,  89,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779,  40,  90,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779, 151, 211,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779, 152, 212,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779, 153, 213,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779, 154, 214,   5, -.1000,  .0000,  .0000
NGEN ,   2, 779, 155, 215,   5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N, 736,    5.852,   6.523,    .750
N, 737,    6.657,   6.867,   1.500
N, 738,    5.852,   8.273,    .750
N, 739,    6.657,   8.272,   1.500
N, 740,    5.852,   6.523,   2.250
N, 741,    5.852,   8.273,   2.250
N, 742,    5.096,   6.073,   1.500
N, 743,    5.097,   8.274,   1.500
N, 744,   16.714,   7.582,   1.500
N, 745,   17.461,   6.836,   2.500
N, 746,   18.615,   5.681,   1.500
N, 747,   17.461,   6.836,    .500
N, 748,    6.003,  -5.542,   1.500
N, 749,    5.324,  -4.782,    .625
N, 750,    5.254,  -5.555,   1.500
N, 751,    4.796,  -4.791,    .625
N, 752,    4.504,  -5.569,   1.500
N, 753,    4.268,  -4.801,    .625
N, 754,    3.754,  -5.582,   1.500
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N, 755,    3.740,   -4.810,    .625
N, 756,    5.324,   -4.782,   2.375
N, 757,    4.796,   -4.791,   2.375
N, 758,    4.268,   -4.801,   2.375
N, 759,    3.740,   -4.810,   2.375
N, 760,    4.753,   -3.878,   1.500
N, 761,    4.410,   -3.884,   1.500
N, 762,    4.067,   -3.890,   1.500
N, 763,    3.724,   -3.896,   1.500
N, 764,   15.788,   -6.048,   2.000
N, 765,   15.137,   -6.485,   1.500
N, 766,   16.178,   -7.323,   2.000
N, 767,   15.494,   -7.651,   1.500
N, 768,   16.567,   -8.598,   2.000
N, 769,   15.850,   -8.817,   1.500
N, 770,   15.788,   -6.048,   1.000
N, 771,   16.178,   -7.323,   1.000
N, 772,   16.567,   -8.598,   1.000
N, 773,   16.215,   -5.709,   1.500
N, 774,   16.634,   -7.080,   1.500
N, 775,   17.053,   -8.450,   1.500
N, 776,    1.625,     .000,   1.500
N, 777,   19.625,     .000,   1.500
N, 778,    5.852,    4.773,   1.500
N, 779,    6.753,   -6.404,   1.500
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,    1,    2,    7,    6, 246, 247, 252, 251
EGEN,    4,    1,    1,    1,    1
EGEN,   23,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E, 121, 122, 127, 126, 366, 367, 372, 371
EGEN,    4,    1,   93,   93,    1
EGEN,   24,    5,   93,   96,    1
EGEN,    2,  245,   93,  188,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R, 1, 10.0
REAL, 1
E, 815, 36
EGEN,  11,   5, 285, 285,   1
EGEN,   5,   1, 285, 295,   1
E, 930, 151
EGEN,  13,   5, 340, 340,   1
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EGEN,   5,   1, 340, 352,   1
/COM *****ATTACHMENT QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2, .100
REAL, 2
E, 292, 298, 737, 736
E, 736, 737, 739, 738
E, 298, 294, 740, 737
E, 737, 740, 741, 739
E, 294, 288, 742, 740
E, 740, 742, 743, 741
E, 288, 292, 736, 742
E, 742, 736, 738, 743
R, 3, .200
REAL, 3
E, 318, 324, 745, 744
E, 324, 328, 746, 745
E, 328, 322, 747, 746
E, 322, 318, 744, 747
R, 4, .300
REAL, 4
E, 658, 652, 749, 748
E, 748, 749, 751, 750
E, 750, 751, 753, 752
E, 752, 753, 755, 754
E, 658, 654, 756, 748
E, 748, 756, 757, 750
E, 750, 757, 758, 752
E, 752, 758, 759, 754
E, 648, 652, 749, 760
E, 760, 749, 751, 761
E, 761, 751, 753, 762
E, 762, 753, 755, 763
E, 648, 654, 756, 760
E, 760, 756, 757, 761
E, 761, 757, 758, 762
E, 762, 758, 759, 763
R, 5, .400
REAL, 5
E, 694, 688, 765, 764
E, 764, 765, 767, 766
E, 766, 767, 769, 768
E, 692, 688, 765, 770
E, 770, 765, 767, 771
E, 771, 767, 769, 772
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E, 694, 698, 773, 764
E, 764, 773, 774, 766
E, 766, 774, 775, 768
E, 692, 698, 773, 770
E, 770, 773, 774, 771
E, 771, 774, 775, 772
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   6,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,   6
E , 738, 739
E , 739, 741
E , 741, 743
E , 743, 738
E , 754, 755
E , 754, 759
E , 763, 755
E , 763, 759
R,   7,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,   7
E ,  13, 776
E , 776, 128
R,   8,     .7854,     .0491,     .0491,    1.0000,    1.0000,,,     .0982
REAL,   8
E , 113, 777
E , 777, 233
R,   9,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,   9
E , 738, 778
E , 754, 779
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  815, ALL, 0.0,, 865,   5
D,  816, ALL, 0.0,, 866,   5
D,  817, ALL, 0.0,, 867,   5
D,  818, ALL, 0.0,, 868,   5
D,  819, ALL, 0.0,, 869,   5
D,  930, ALL, 0.0,, 990,   5
D,  931, ALL, 0.0,, 991,   5
D,  932, ALL, 0.0,, 992,   5
D,  933, ALL, 0.0,, 993,   5
D,  934, ALL, 0.0,, 994,   5
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WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  778,FX,        1.000
F,  778,FY,        2.000
F,  778,FZ,        3.000
F,  778,MX,        4.000
F,  778,MY,        5.000
F,  778,MZ,        6.000
F,  779,FX,        7.000
F,  779,FY,        8.000
F,  779,FZ,        9.000
F,  779,MX,       10.000
F,  779,MY,       11.000
F,  779,MZ,       12.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 10

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/PREP7
/TITLE TEST10
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     29999.000
NUXY, 1,  .340
MU, 2,  .150
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.311,   2.563, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.311,  -2.563, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,   1,    .000,    .813,    .000
N,   2,    .000,    .813,    .750
N,   3,    .000,    .813,   1.500
N,   4,    .000,    .813,   2.250
N,   5,    .000,    .813,   3.000
N,   6,   1.625,    .813,    .000
N,   7,   1.625,    .813,    .750
N,   8,   1.625,    .813,   1.500
N,   9,   1.625,    .813,   2.250
N,  10,   1.625,    .813,   3.000
N,  11,   2.187,    .813,    .000
N,  12,   2.187,    .813,    .750
N,  13,   2.187,    .813,   1.500
N,  14,   2.187,    .813,   2.250
N,  15,   2.187,    .813,   3.000
N,  16,   2.749,    .813,    .000
N,  17,   2.749,    .813,    .750
N,  18,   2.749,    .813,   1.500
N,  19,   2.749,    .813,   2.250
N,  20,   2.749,    .813,   3.000
N,  21,   3.311,    .813,    .000
N,  22,   3.311,    .813,    .750
N,  23,   3.311,    .813,   1.500
N,  24,   3.311,    .813,   2.250
N,  25,   3.311,    .813,   3.000
N,  76,  18.060,    .438,    .000
N,  77,  18.060,    .438,    .750
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N,   78,  18.060,   .438,  1.500
N,   79,  18.060,   .438,  2.250
N,   80,  18.060,   .438,  3.000
N,   81,  18.582,   .438,   .000
N,   82,  18.582,   .438,   .750
N,   83,  18.582,   .438,  1.500
N,   84,  18.582,   .438,  2.250
N,   85,  18.582,   .438,  3.000
N,   86,  19.103,   .438,   .000
N,   87,  19.103,   .438,   .750
N,   88,  19.103,   .438,  1.500
N,   89,  19.103,   .438,  2.250
N,   90,  19.103,   .438,  3.000
N,   91,  19.625,   .438,   .000
N,   92,  19.625,   .438,   .750
N,   93,  19.625,   .438,  1.500
N,   94,  19.625,   .438,  2.250
N,   95,  19.625,   .438,  3.000
N,   96,  21.500,   .438,   .000
N,   97,  21.500,   .438,   .750
N,   98,  21.500,   .438,  1.500
N,   99,  21.500,   .438,  2.250
N,  100,  21.500,   .438,  3.000
N,  101,    .000,  -.813,   .000
N,  102,    .000,  -.813,   .750
N,  103,    .000,  -.813,  1.500
N,  104,    .000,  -.813,  2.250
N,  105,    .000,  -.813,  3.000
N,  106,   1.625,  -.813,   .000
N,  107,   1.625,  -.813,   .750
N,  108,   1.625,  -.813,  1.500
N,  109,   1.625,  -.813,  2.250
N,  110,   1.625,  -.813,  3.000
N,  111,   2.187,  -.813,   .000
N,  112,   2.187,  -.813,   .750
N,  113,   2.187,  -.813,  1.500
N,  114,   2.187,  -.813,  2.250
N,  115,   2.187,  -.813,  3.000
N,  116,   2.749,  -.813,   .000
N,  117,   2.749,  -.813,   .750
N,  118,   2.749,  -.813,  1.500
N,  119,   2.749,  -.813,  2.250
N,  120,   2.749,  -.813,  3.000
N,  121,   3.311,  -.813,   .000
N,  122,   3.311,  -.813,   .750
N,  123,   3.311,  -.813,  1.500
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N,  124,    3.311,    -.813,    2.250
N,  125,    3.311,    -.813,    3.000
N,  176,   18.060,    -.438,     .000
N,  177,   18.060,    -.438,     .750
N,  178,   18.060,    -.438,    1.500
N,  179,   18.060,    -.438,    2.250
N,  180,   18.060,    -.438,    3.000
N,  181,   18.582,    -.438,     .000
N,  182,   18.582,    -.438,     .750
N,  183,   18.582,    -.438,    1.500
N,  184,   18.582,    -.438,    2.250
N,  185,   18.582,    -.438,    3.000
N,  186,   19.103,    -.438,     .000
N,  187,   19.103,    -.438,     .750
N,  188,   19.103,    -.438,    1.500
N,  189,   19.103,    -.438,    2.250
N,  190,   19.103,    -.438,    3.000
N,  191,   19.625,    -.438,     .000
N,  192,   19.625,    -.438,     .750
N,  193,   19.625,    -.438,    1.500
N,  194,   19.625,    -.438,    2.250
N,  195,   19.625,    -.438,    3.000
N,  196,   21.500,    -.438,     .000
N,  197,   21.500,    -.438,     .750
N,  198,   21.500,    -.438,    1.500
N,  199,   21.500,    -.438,    2.250
N,  200,   21.500,    -.438,    3.000
CSYS, 11
N,   31,    6.000,  160.692,     .000
N,   32,    6.000,  160.692,     .750
N,   33,    6.000,  160.692,    1.500
N,   34,    6.000,  160.692,    2.250
N,   35,    6.000,  160.692,    3.000
N,   36,    6.000,  140.078,     .000
N,   37,    6.000,  140.078,     .750
N,   38,    6.000,  140.078,    1.500
N,   39,    6.000,  140.078,    2.250
N,   40,    6.000,  140.078,    3.000
N,   41,    6.000,  119.464,     .000
N,   42,    6.000,  119.464,     .750
N,   43,    6.000,  119.464,    1.500
N,   44,    6.000,  119.464,    2.250
N,   45,    6.000,  119.464,    3.000
N,   46,    6.000,   98.850,     .000
N,   47,    6.000,   98.850,     .750
N,   48,    6.000,   98.850,    1.500
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N,	49,	6.000,	98.850,	2.250
N,	50,	6.000,	98.850,	3.000
N,	51,	6.000,	78.237,	.000
N,	52,	6.000,	78.237,	.750
N,	53,	6.000,	78.237,	1.500
N,	54,	6.000,	78.237,	2.250
N,	55,	6.000,	78.237,	3.000
N,	56,	6.000,	57.623,	.000
N,	57,	6.000,	57.623,	.750
N,	58,	6.000,	57.623,	1.500
N,	59,	6.000,	57.623,	2.250
N,	60,	6.000,	57.623,	3.000
N,	61,	6.000,	37.009,	.000
N,	62,	6.000,	37.009,	.750
N,	63,	6.000,	37.009,	1.500
N,	64,	6.000,	37.009,	2.250
N,	65,	6.000,	37.009,	3.000
N,	66,	6.000,	16.395,	.000
N,	67,	6.000,	16.395,	.750
N,	68,	6.000,	16.395,	1.500
N,	69,	6.000,	16.395,	2.250
N,	70,	6.000,	16.395,	3.000
N,	131,	6.000,	-160.692,	.000
N,	132,	6.000,	-160.692,	.750
N,	133,	6.000,	-160.692,	1.500
N,	134,	6.000,	-160.692,	2.250
N,	135,	6.000,	-160.692,	3.000
N,	136,	6.000,	-140.078,	.000
N,	137,	6.000,	-140.078,	.750
N,	138,	6.000,	-140.078,	1.500
N,	139,	6.000,	-140.078,	2.250
N,	140,	6.000,	-140.078,	3.000
N,	141,	6.000,	-119.464,	.000
N,	142,	6.000,	-119.464,	.750
N,	143,	6.000,	-119.464,	1.500
N,	144,	6.000,	-119.464,	2.250
N,	145,	6.000,	-119.464,	3.000
N,	146,	6.000,	-98.850,	.000
N,	147,	6.000,	-98.850,	.750
N,	148,	6.000,	-98.850,	1.500
N,	149,	6.000,	-98.850,	2.250
N,	150,	6.000,	-98.850,	3.000
N,	151,	6.000,	-78.237,	.000
N,	152,	6.000,	-78.237,	.750
N,	153,	6.000,	-78.237,	1.500
N,	154,	6.000,	-78.237,	2.250

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N,  155,    6.000,  -78.237,    3.000
N,  156,    6.000,  -57.623,     .000
N,  157,    6.000,  -57.623,     .750
N,  158,    6.000,  -57.623,    1.500
N,  159,    6.000,  -57.623,    2.250
N,  160,    6.000,  -57.623,    3.000
N,  161,    6.000,  -37.009,     .000
N,  162,    6.000,  -37.009,     .750
N,  163,    6.000,  -37.009,    1.500
N,  164,    6.000,  -37.009,    2.250
N,  165,    6.000,  -37.009,    3.000
N,  166,    6.000,  -16.395,     .000
N,  167,    6.000,  -16.395,     .750
N,  168,    6.000,  -16.395,    1.500
N,  169,    6.000,  -16.395,    2.250
N,  170,    6.000,  -16.395,    3.000
CSYS, 12
N,   26,    1.750,  -54.654,     .000
N,   27,    1.750,  -54.654,     .750
N,   28,    1.750,  -54.654,    1.500
N,   29,    1.750,  -54.654,    2.250
N,   30,    1.750,  -54.654,    3.000
CSYS, 13
N,   71,    1.750, -126.802,     .000
N,   72,    1.750, -126.802,     .750
N,   73,    1.750, -126.802,    1.500
N,   74,    1.750, -126.802,    2.250
N,   75,    1.750, -126.802,    3.000
CSYS, 14
N,  126,    1.750,   54.654,     .000
N,  127,    1.750,   54.654,     .750
N,  128,    1.750,   54.654,    1.500
N,  129,    1.750,   54.654,    2.250
N,  130,    1.750,   54.654,    3.000
CSYS, 15
N,  171,    1.750,  126.802,     .000
N,  172,    1.750,  126.802,     .750
N,  173,    1.750,  126.802,    1.500
N,  174,    1.750,  126.802,    2.250
N,  175,    1.750,  126.802,    3.000
CSYS,  0
NGEN ,    2,  200,    1,   25,    1,  .0000,  .7500,  .0000
CSYS, 12
NGEN ,    2,  200,   26,   30,    1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,    2,  200,   31,   70,    1,  .7500,  .0000,  .0000
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CSYS, 13
NGEN ,    2,  200,   71,   75,    1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2,  200,   76,  100,    1,  .0000,  .7500,  .0000
CSYS,  0
NGEN ,    4,  200,  101,  125,    1,  .0000, -.2500,  .0000
CSYS, 14
NGEN ,    4,  200,  126,  130,    1, -.2500,  .0000,  .0000
CSYS, 11
NGEN ,    4,  200,  131,  170,    1,  .2500,  .0000,  .0000
CSYS, 15
NGEN ,    4,  200,  171,  175,    1, -.2500,  .0000,  .0000
CSYS,  0
NGEN ,    4,  200,  176,  200,    1,  .0000, -.2500,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  803,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,   34,   69,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2,  803,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N, 801,    1.625,     .000,    1.500
N, 802,   19.625,     .000,    1.500
N, 803,   17.101,   12.708,    8.600
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,    1,    2,    7,    6,  201,  202,  207,  206
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E,  101,  102,  107,  106,  301,  302,  307,  306
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
EGEN,    3,  200,   77,  152,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R, 1, 10.0
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REAL,  1
E, 834,  31
EGEN,  8,  5, 305, 305,  1
EGEN,  5,  1, 305, 312,  1
E, 934, 131
EGEN,  8,  5, 345, 345,  1
EGEN,  5,  1, 345, 352,  1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  2,    1.3200,    .1331,    .1584,    1.2000,    1.1000,,,     .3131
REAL,  2
E ,  211,  241
E ,  215,  245
R,  3,    4.6200,   1.6978,   1.8634,    2.2000,    2.1000,,,    3.9933
REAL,  3
E ,  711,  741
R,  4,    5.5200,   2.4334,   2.6496,    2.4000,    2.3000,,,    5.7234
REAL,  4
E ,  715,  745
R,  5,    6.0000,   3.1250,   2.8800,    2.4000,    2.5000,,,    6.7738
REAL,  5
E ,  286,  261
R,  6,    8.1200,   5.6908,   5.3051,    2.8000,    2.9000,,,   12.4775
REAL,  6
E ,  290,  265
R,  7,    1.3200,    .1331,    .1584,    1.2000,    1.1000,,,     .3131
REAL,  7
E ,  786,  761
E ,  790,  765
R,  8,  100.0000, 999.0000, 999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  8
E ,  253,  259
E ,  259,  265
R,  9,    1.7671,    .2485,    .2485,    1.5000,    1.5000,,,     .4970
REAL,  9
E ,    8,  801
E ,  801,  108
E ,   93,  802
E ,  802,  193
R,  10,  100.0000, 999.0000, 999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  10
E ,  253,  803
LOADS
CSYS, 0
ITER, -20, 20, 20
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KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D, 834, ALL, 0.0,, 869,  5
D, 835, ALL, 0.0,, 870,  5
D, 836, ALL, 0.0,, 871,  5
D, 837, ALL, 0.0,, 872,  5
D, 838, ALL, 0.0,, 873,  5
D, 934, ALL, 0.0,, 969,  5
D, 935, ALL, 0.0,, 970,  5
D, 936, ALL, 0.0,, 971,  5
D, 937, ALL, 0.0,, 972,  5
D, 938, ALL, 0.0,, 973,  5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F, 803,FX,       1.111
F, 803,FY,       2.222
F, 803,FZ,       3.333
F, 803,MX,       4.444
F, 803,MY,       5.555
F, 803,MZ,       6.666
LWRITE
/COM *****LOAD CASE NO.  2*****
FDELE, 803,FX
FDELE, 803,FY
FDELE, 803,FZ
FDELE, 803,MX
FDELE, 803,MY
FDELE, 803,MZ
F, 803,FX,      -1.111
F, 803,FY,      -2.222
F, 803,FZ,      -3.333
F, 803,MX,      -4.444
F, 803,MY,      -5.555
F, 803,MZ,      -6.666
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 11

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/PREP7
/TITLE TEST11
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.774,   1.438, 0.0
LOCAL, 13, 1,  17.386,   1.813, 0.0
LOCAL, 14, 1,   2.825,  -2.688, 0.0
LOCAL, 15, 1,  18.286,  -3.063, 0.0
CSYS, 0
N,    1,     .000,     .438,     .000
N,    2,     .000,     .438,     .750
N,    3,     .000,     .438,    1.500
N,    4,     .000,     .438,    2.250
N,    5,     .000,     .438,    3.000
N,    6,    1.625,     .438,     .000
N,    7,    1.625,     .438,     .750
N,    8,    1.625,     .438,    1.500
N,    9,    1.625,     .438,    2.250
N,   10,    1.625,     .438,    3.000
N,   11,    2.341,     .438,     .000
N,   12,    2.341,     .438,     .750
N,   13,    2.341,     .438,    1.500
N,   14,    2.341,     .438,    2.250
N,   15,    2.341,     .438,    3.000
N,   16,    3.058,     .438,     .000
N,   17,    3.058,     .438,     .750
N,   18,    3.058,     .438,    1.500
N,   19,    3.058,     .438,    2.250
N,   20,    3.058,     .438,    3.000
N,   21,    3.774,     .438,     .000
N,   22,    3.774,     .438,     .750
N,   23,    3.774,     .438,    1.500
N,   24,    3.774,     .438,    2.250
N,   25,    3.774,     .438,    3.000
N,   76,   17.386,     .813,     .000
N,   77,   17.386,     .813,     .750
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N,  78,  17.386,   .813,  1.500
N,  79,  17.386,   .813,  2.250
N,  80,  17.386,   .813,  3.000
N,  81,  18.133,   .813,   .000
N,  82,  18.133,   .813,   .750
N,  83,  18.133,   .813,  1.500
N,  84,  18.133,   .813,  2.250
N,  85,  18.133,   .813,  3.000
N,  86,  18.879,   .813,   .000
N,  87,  18.879,   .813,   .750
N,  88,  18.879,   .813,  1.500
N,  89,  18.879,   .813,  2.250
N,  90,  18.879,   .813,  3.000
N,  91,  19.625,   .813,   .000
N,  92,  19.625,   .813,   .750
N,  93,  19.625,   .813,  1.500
N,  94,  19.625,   .813,  2.250
N,  95,  19.625,   .813,  3.000
N,  96,  21.500,   .813,   .000
N,  97,  21.500,   .813,   .750
N,  98,  21.500,   .813,  1.500
N,  99,  21.500,   .813,  2.250
N, 100,  21.500,   .813,  3.000
N, 101,    .000,  -.813,   .000
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N, 123,   2.825,  -.813,  1.500
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N,  185,   18.732,   -1.188,    3.000
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N,  191,   19.625,   -1.188,     .000
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N,  194,   19.625,   -1.188,    2.250
N,  195,   19.625,   -1.188,    3.000
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N,   37,    6.000,  146.272,     .750
N,   38,    6.000,  146.272,    1.500
N,   39,    6.000,  146.272,    2.250
N,   40,    6.000,  146.272,    3.000
N,   41,    6.000,  124.394,     .000
N,   42,    6.000,  124.394,     .750
N,   43,    6.000,  124.394,    1.500
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N,	52,	6.000,	80.639,	.750
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N,	55,	6.000,	80.639,	3.000
N,	56,	6.000,	58.762,	.000
N,	57,	6.000,	58.762,	.750
N,	58,	6.000,	58.762,	1.500
N,	59,	6.000,	58.762,	2.250
N,	60,	6.000,	58.762,	3.000
N,	61,	6.000,	36.884,	.000
N,	62,	6.000,	36.884,	.750
N,	63,	6.000,	36.884,	1.500
N,	64,	6.000,	36.884,	2.250
N,	65,	6.000,	36.884,	3.000
N,	66,	6.000,	15.007,	.000
N,	67,	6.000,	15.007,	.750
N,	68,	6.000,	15.007,	1.500
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N,	70,	6.000,	15.007,	3.000
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N,	132,	6.375,	-160.988,	.750
N,	133,	6.375,	-160.988,	1.500
N,	134,	6.375,	-160.988,	2.250
N,	135,	6.375,	-160.988,	3.000
N,	136,	6.375,	-141.103,	.000
N,	137,	6.375,	-141.103,	.750
N,	138,	6.375,	-141.103,	1.500
N,	139,	6.375,	-141.103,	2.250
N,	140,	6.375,	-141.103,	3.000
N,	141,	6.375,	-121.218,	.000
N,	142,	6.375,	-121.218,	.750
N,	143,	6.375,	-121.218,	1.500
N,	144,	6.375,	-121.218,	2.250
N,	145,	6.375,	-121.218,	3.000
N,	146,	6.375,	-101.332,	.000
N,	147,	6.375,	-101.332,	.750
N,	148,	6.375,	-101.332,	1.500
N,	149,	6.375,	-101.332,	2.250
N,	150,	6.375,	-101.332,	3.000
N,	151,	6.375,	-81.447,	.000
N,	152,	6.375,	-81.447,	.750
N,	153,	6.375,	-81.447,	1.500
N,	154,	6.375,	-81.447,	2.250

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N,  155,    6.375,  -81.447,    3.000
N,  156,    6.375,  -61.561,     .000
N,  157,    6.375,  -61.561,     .750
N,  158,    6.375,  -61.561,    1.500
N,  159,    6.375,  -61.561,    2.250
N,  160,    6.375,  -61.561,    3.000
N,  161,    6.375,  -41.676,     .000
N,  162,    6.375,  -41.676,     .750
N,  163,    6.375,  -41.676,    1.500
N,  164,    6.375,  -41.676,    2.250
N,  165,    6.375,  -41.676,    3.000
N,  166,    6.375,  -21.790,     .000
N,  167,    6.375,  -21.790,     .750
N,  168,    6.375,  -21.790,    1.500
N,  169,    6.375,  -21.790,    2.250
N,  170,    6.375,  -21.790,    3.000
CSYS, 12
N,   26,    1.000,  -50.925,     .000
N,   27,    1.000,  -50.925,     .750
N,   28,    1.000,  -50.925,    1.500
N,   29,    1.000,  -50.925,    2.250
N,   30,    1.000,  -50.925,    3.000
CSYS, 13
N,   71,    1.000, -127.497,     .000
N,   72,    1.000, -127.497,     .750
N,   73,    1.000, -127.497,    1.500
N,   74,    1.000, -127.497,    2.250
N,   75,    1.000, -127.497,    3.000
CSYS, 14
N,  126,    1.875,   54.506,     .000
N,  127,    1.875,   54.506,     .750
N,  128,    1.875,   54.506,    1.500
N,  129,    1.875,   54.506,    2.250
N,  130,    1.875,   54.506,    3.000
CSYS, 15
N,  171,    1.875,  124.105,     .000
N,  172,    1.875,  124.105,     .750
N,  173,    1.875,  124.105,    1.500
N,  174,    1.875,  124.105,    2.250
N,  175,    1.875,  124.105,    3.000
CSYS,  0
NGEN ,    2,  200,    1,   25,    1,  .0000,  .5000,  .0000
CSYS, 12
NGEN ,    2,  200,   26,   30,    1, -.5000,  .0000,  .0000
CSYS, 11
NGEN ,    2,  200,   31,   70,    1,  .5000,  .0000,  .0000
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CSYS, 13
NGEN ,    2, 200,   71,   75,    1, -.5000,  .0000,  .0000
CSYS,  0
NGEN ,    2, 200,   76,  100,    1,  .0000,  .5000,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2, 475,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,   34,   69,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2, 475,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  401,     5.219,    6.609,     .750
N,  402,     6.951,    6.607,    1.500
N,  403,     9.214,    6.605,    2.250
N,  404,    11.679,    6.603,    2.250
N,  405,    13.994,    6.600,    2.250
N,  406,    15.824,    6.599,    2.250
N,  407,    15.824,    6.599,    1.500
N,  408,    15.824,    6.599,     .750
N,  409,    15.824,    6.599,     .000
N,  410,    13.994,    6.600,     .000
N,  411,    11.679,    6.603,     .000
N,  412,      .000,   -3.605,    1.500
N,  413,     1.625,   -3.605,    1.500
N,  414,      .000,   -6.396,    1.500
N,  415,     1.625,   -6.397,    1.500
N,  416,      .000,   -9.188,    1.500
N,  417,     1.625,   -9.190,    1.500
N,  418,     2.025,   -3.605,    1.500
N,  419,     2.025,   -6.398,    1.500
N,  420,     2.025,   -9.190,    1.500
N,  421,     2.425,   -3.605,    1.500
N,  422,     2.425,   -6.398,    1.500
N,  423,     2.425,   -9.190,    1.500
N,  424,     2.825,   -3.606,    1.500
N,  425,     2.825,   -6.398,    1.500
N,  426,     2.825,   -9.191,    1.500
N,  427,     3.914,   -3.838,    1.500
N,  428,     3.914,   -6.515,    1.500
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N,	429,	3.914,	-9.192,	1.500
N,	430,	4.598,	-4.449,	1.500
N,	431,	4.599,	-6.821,	1.500
N,	432,	4.599,	-9.193,	1.500
N,	433,	5.665,	-5.733,	1.500
N,	434,	5.666,	-7.463,	1.500
N,	435,	5.667,	-9.194,	1.500
N,	436,	7.322,	-6.700,	1.500
N,	437,	7.324,	-7.948,	1.500
N,	438,	7.325,	-9.195,	1.500
N,	439,	9.374,	-7.233,	1.500
N,	440,	9.376,	-8.215,	1.500
N,	441,	9.378,	-9.197,	1.500
N,	442,	11.575,	-7.269,	1.500
N,	443,	11.577,	-8.234,	1.500
N,	444,	11.579,	-9.200,	1.500
N,	445,	13.663,	-6.804,	1.500
N,	446,	13.664,	-8.003,	1.500
N,	447,	13.666,	-9.202,	1.500
N,	448,	15.388,	-5.894,	1.500
N,	449,	15.389,	-7.549,	1.500
N,	450,	15.390,	-9.203,	1.500
N,	451,	16.545,	-4.646,	1.500
N,	452,	16.546,	-6.925,	1.500
N,	453,	16.546,	-9.205,	1.500
N,	454,	17.234,	-4.075,	1.500
N,	455,	17.235,	-6.640,	1.500
N,	456,	17.235,	-9.205,	1.500
N,	457,	18.286,	-3.861,	1.500
N,	458,	18.286,	-6.534,	1.500
N,	459,	18.286,	-9.206,	1.500
N,	460,	18.732,	-3.861,	1.500
N,	461,	18.732,	-6.534,	1.500
N,	462,	18.732,	-9.207,	1.500
N,	463,	19.179,	-3.861,	1.500
N,	464,	19.179,	-6.534,	1.500
N,	465,	19.179,	-9.207,	1.500
N,	466,	19.625,	-3.861,	1.500
N,	467,	19.625,	-6.534,	1.500
N,	468,	19.625,	-9.208,	1.500
N,	469,	21.500,	-3.862,	1.500
N,	470,	21.500,	-6.536,	1.500
N,	471,	21.500,	-9.210,	1.500
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N,	474,	5.219,	3.609,	.750

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N, 475,    .500,    -.588,    2.200
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,   1,   2,   7,   6,  201,  202,  207,  206
EGEN,   4,   1,   1,   1,   1
EGEN,  19,   5,   1,   4,   1
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,   .750
REAL,  2
E, 101, 102, 107, 106
EGEN,   4,   1,  77,  77,   1
EGEN,  19,   5,  77,  80,   1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  2, 10.0
REAL,  2
E, 506,  31
EGEN,   8,   5, 153, 153,   1
EGEN,   5,   1, 153, 160,   1
E, 606, 131
EGEN,   8,   5, 193, 193,   1
EGEN,   5,   1, 193, 200,   1
/COM *****ATTACHMENT QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R,  3,  .100
REAL,  3
E,  237,  243,  402,  401
E,  243,  249,  403,  402
E,  249,  254,  404,  403
E,  254,  259,  405,  404
E,  259,  264,  406,  405
E,  264,  263,  407,  406
E,  263,  262,  408,  407
E,  262,  261,  409,  408
E,  261,  256,  410,  409
E,  256,  251,  411,  410
R,  4,  .200
REAL,  4
E,  103,  108,  413,  412
E,  412,  413,  415,  414
E,  414,  415,  417,  416
E,  108,  113,  418,  413
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E, 415, 419, 420, 417
E, 113, 118, 421, 418
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E, 419, 422, 423, 420
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E, 168, 173, 454, 451
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E, 173, 178, 457, 454
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E, 455, 458, 459, 456
E, 178, 183, 460, 457
E, 457, 460, 461, 458
E, 458, 461, 462, 459
E, 183, 188, 463, 460
E, 460, 463, 464, 461
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E, 461, 464, 465, 462
E, 188, 193, 466, 463
E, 463, 466, 467, 464
E, 464, 467, 468, 465
E, 193, 198, 469, 466
E, 466, 469, 470, 467
E, 467, 470, 471, 468
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   5,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,   5
E , 401, 402
E , 402, 403
E , 403, 404
E , 404, 405
E , 405, 406
E , 406, 407
E , 407, 408
E , 408, 409
E , 409, 410
E , 410, 411
E , 416, 417
E , 417, 420
E , 420, 423
E , 423, 426
E , 426, 429
E , 429, 432
E , 432, 435
E , 435, 438
E , 438, 441
E , 441, 444
E , 444, 447
E , 447, 450
E , 450, 453
E , 453, 456
E , 456, 459
E , 459, 462
E , 462, 465
E , 465, 468
E , 468, 471
R,   6,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,   6
E ,   8, 472
E , 472, 108
E ,  93, 473
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E , 473, 193
R, 7, 100.0000, 999.0000, 999.0000,    1.0000,    1.0000,,, 999.0000
REAL,  7
E , 401, 474
E , 416, 475
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D, 506, ALL, 0.0,, 541,  5
D, 507, ALL, 0.0,, 542,  5
D, 508, ALL, 0.0,, 543,  5
D, 509, ALL, 0.0,, 544,  5
D, 510, ALL, 0.0,, 545,  5
D, 606, ALL, 0.0,, 641,  5
D, 607, ALL, 0.0,, 642,  5
D, 608, ALL, 0.0,, 643,  5
D, 609, ALL, 0.0,, 644,  5
D, 610, ALL, 0.0,, 645,  5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F, 474,FX,       1.000
F, 474,FY,       2.000
F, 474,FZ,       3.000
F, 474,MX,       4.000
F, 474,MY,       5.000
F, 474,MZ,       6.000
F, 475,FX,       7.000
F, 475,FY,       8.000
F, 475,FZ,       9.000
F, 475,MX,      10.000
F, 475,MY,      11.000
F, 475,MZ,      12.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 12

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/PREP7
/TITLE TEST12
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,      30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  11.000,   0.0,    0.0
LOCAL, 12, 1,   5.822,   2.500, 0.0
LOCAL, 13, 1,  16.292,   2.250, 0.0
LOCAL, 14, 1,   5.371,  -3.250, 0.0
LOCAL, 15, 1,  16.766,  -3.000, 0.0
CSYS, 0
N,    1,     .000,     .750,     .000
N,    2,     .000,     .750,     .625
N,    3,     .000,     .750,    1.250
N,    4,     .000,     .750,    2.000
N,    5,     .000,     .750,    2.750
N,    6,     .000,     .750,    3.375
N,    7,     .000,     .750,    4.000
N,    8,    1.000,     .750,     .000
N,    9,    1.000,     .750,     .625
N,   10,    1.000,     .750,    1.250
N,   11,    1.000,     .750,    2.000
N,   12,    1.000,     .750,    2.750
N,   13,    1.000,     .750,    3.375
N,   14,    1.000,     .750,    4.000
N,   15,    2.000,     .750,     .000
N,   16,    2.000,     .750,     .625
N,   17,    2.000,     .750,    1.250
N,   18,    2.000,     .750,    2.000
N,   19,    2.000,     .750,    2.750
N,   20,    2.000,     .750,    3.375
N,   21,    2.000,     .750,    4.000
N,   22,    2.750,     .750,     .000
N,   23,    2.750,     .750,     .625
N,   24,    2.750,     .750,    1.250
N,   25,    2.750,     .750,    2.000
N,   26,    2.750,     .750,    2.750
N,   27,    2.750,     .750,    3.375
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N,	28,	2.750,	.750,	4.000
N,	29,	3.500,	.750,	.000
N,	30,	3.500,	.750,	.625
N,	31,	3.500,	.750,	1.250
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/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,   2, 949,  71, 155,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949,  72, 156,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949,  73, 157,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949,  74, 158,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949,  75, 159,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949,  76, 160,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949,  77, 161,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949, 288, 372,   7, -.1000,  .0000,  .0000
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NGEN ,   2, 949, 290, 374,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949, 291, 375,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949, 292, 376,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949, 293, 377,   7, -.1000,  .0000,  .0000
NGEN ,   2, 949, 294, 378,   7, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N, 869,   7.219,   4.265,   1.250
N, 870,   6.564,   3.960,   1.250
N, 871,   5.968,   3.682,   1.250
N, 872,   5.673,   3.544,   1.250
N, 873,   5.339,   3.388,   1.250
N, 874,   5.012,   3.236,   1.250
N, 875,   4.469,   2.983,   1.250
N, 876,   3.926,   2.730,   1.250
N, 877,   3.105,   2.347,   1.250
N, 878,   7.219,   4.265,   2.750
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N,	880,	5.968,	3.682,	2.750
N,	881,	5.673,	3.544,	2.750
N,	882,	5.339,	3.388,	2.750
N,	883,	5.012,	3.236,	2.750
N,	884,	4.469,	2.983,	2.750
N,	885,	3.926,	2.730,	2.750
N,	886,	3.105,	2.347,	2.750
N,	887,	14.859,	4.225,	1.250
N,	888,	15.596,	3.799,	1.250
N,	889,	16.268,	3.411,	1.250
N,	890,	16.569,	3.237,	1.250
N,	891,	16.904,	3.044,	1.250
N,	892,	17.221,	2.861,	1.250
N,	893,	17.649,	2.614,	1.250
N,	894,	18.076,	2.367,	1.250
N,	895,	18.503,	2.121,	1.250
N,	896,	19.065,	1.796,	1.250
N,	897,	14.859,	4.225,	2.750
N,	898,	15.596,	3.799,	2.750
N,	899,	16.268,	3.411,	2.750
N,	900,	16.569,	3.237,	2.750
N,	901,	16.904,	3.044,	2.750
N,	902,	17.221,	2.861,	2.750
N,	903,	17.649,	2.614,	2.750
N,	904,	18.076,	2.367,	2.750
N,	905,	18.503,	2.121,	2.750
N,	906,	19.065,	1.796,	2.750
N,	907,	7.042,	-4.442,	1.250
N,	908,	6.499,	-4.189,	1.250
N,	909,	5.993,	-3.953,	1.250
N,	910,	5.565,	-3.753,	1.250
N,	911,	5.094,	-3.534,	1.250
N,	912,	4.638,	-3.321,	1.250
N,	913,	4.281,	-3.154,	1.250
N,	914,	3.923,	-2.987,	1.250
N,	915,	3.102,	-2.604,	1.250
N,	916,	7.042,	-4.442,	2.750
N,	917,	6.499,	-4.189,	2.750
N,	918,	5.993,	-3.953,	2.750
N,	919,	5.565,	-3.753,	2.750
N,	920,	5.094,	-3.534,	2.750
N,	921,	4.638,	-3.321,	2.750
N,	922,	4.281,	-3.154,	2.750
N,	923,	3.923,	-2.987,	2.750
N,	924,	3.102,	-2.604,	2.750

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N, 926,  15.659,  -4.041,   1.250
N, 927,  16.242,  -3.705,   1.250
N, 928,  16.678,  -3.454,   1.250
N, 929,  17.147,  -3.182,   1.250
N, 930,  17.590,  -2.927,   1.250
N, 931,  17.898,  -2.749,   1.250
N, 932,  18.207,  -2.571,   1.250
N, 933,  18.515,  -2.393,   1.250
N, 934,  19.078,  -2.068,   1.250
N, 935,  15.036,  -4.402,   2.750
N, 936,  15.659,  -4.041,   2.750
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N, 947,   4.500,    .000,   2.000
N, 948,  18.000,    .000,   2.000
N, 949,  10.851,   4.609,   2.000
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,    1,    2,    9,    8, 435, 436, 443, 442
EGEN,   6,    1,    1,    1,    1
EGEN,  30,    7,    1,    6,    1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E, 218, 219, 226, 225, 652, 653, 660, 659
EGEN,   6,    1, 181, 181,    1
EGEN,  30,    7, 181, 186,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R, 1, 10.0
REAL, 1
E,1020,  71
EGEN,  13,   7, 361, 361,   1
EGEN,   7,   1, 361, 373,   1
E,1237, 288
EGEN,  13,   7, 452, 452,   1
EGEN,   7,   1, 452, 464,   1
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/COM *****ATTACHMENT QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2, .500
REAL, 2
E, 521, 514, 870, 869
E, 514, 507, 871, 870
E, 507, 500, 872, 871
E, 500, 493, 873, 872
E, 493, 486, 874, 873
E, 486, 479, 875, 874
E, 479, 472, 876, 875
E, 472, 465, 877, 876
E, 523, 516, 879, 878
E, 516, 509, 880, 879
E, 509, 502, 881, 880
E, 502, 495, 882, 881
E, 495, 488, 883, 882
E, 488, 481, 884, 883
E, 481, 474, 885, 884
E, 474, 467, 886, 885
E, 577, 584, 888, 887
E, 584, 591, 889, 888
E, 591, 598, 890, 889
E, 598, 605, 891, 890
E, 605, 612, 892, 891
E, 612, 619, 893, 892
E, 619, 626, 894, 893
E, 626, 633, 895, 894
E, 633, 640, 896, 895
E, 579, 586, 898, 897
E, 586, 593, 899, 898
E, 593, 600, 900, 899
E, 600, 607, 901, 900
E, 607, 614, 902, 901
E, 614, 621, 903, 902
E, 621, 628, 904, 903
E, 628, 635, 905, 904
E, 635, 642, 906, 905
E, 738, 731, 908, 907
E, 731, 724, 909, 908
E, 724, 717, 910, 909
E, 717, 710, 911, 910
E, 710, 703, 912, 911
E, 703, 696, 913, 912
E, 696, 689, 914, 913
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E, 689, 682, 915, 914
E, 740, 733, 917, 916
E, 733, 726, 918, 917
E, 726, 719, 919, 918
E, 719, 712, 920, 919
E, 712, 705, 921, 920
E, 705, 698, 922, 921
E, 698, 691, 923, 922
E, 691, 684, 924, 923
E, 794, 801, 926, 925
E, 801, 808, 927, 926
E, 808, 815, 928, 927
E, 815, 822, 929, 928
E, 822, 829, 930, 929
E, 829, 836, 931, 930
E, 836, 843, 932, 931
E, 843, 850, 933, 932
E, 850, 857, 934, 933
E, 796, 803, 936, 935
E, 803, 810, 937, 936
E, 810, 817, 938, 937
E, 817, 824, 939, 938
E, 824, 831, 940, 939
E, 831, 838, 941, 940
E, 838, 845, 942, 941
E, 845, 852, 943, 942
E, 852, 859, 944, 943
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  3, 100.0000, 999.0000, 999.0000,   1.0000,   1.0000,,, 999.0000
REAL,  3
E ,  542, 549
E ,  549, 556
E ,  556, 557
E ,  557, 558
E ,  558, 551
E ,  551, 544
E ,  544, 543
E ,  543, 542
R,  4,   .4418,   .0155,   .0155,   .7500,   .7500,,,   .0311
REAL,  4
E ,   17, 945
E ,  945, 234
E ,   19, 946
E ,  946, 236
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R,   5,    .7854,     .0491,     .0491,    1.0000,    1.0000,,,     .0982
REAL,  5
E ,  39,  947
E ,  947,  256
E ,  200,  948
E ,  948,  417
R,   6,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  6
E ,  542,  949
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D, 1020, ALL, 0.0,,1104,   7
D, 1021, ALL, 0.0,,1105,   7
D, 1022, ALL, 0.0,,1106,   7
D, 1023, ALL, 0.0,,1107,   7
D, 1024, ALL, 0.0,,1108,   7
D, 1025, ALL, 0.0,,1109,   7
D, 1026, ALL, 0.0,,1110,   7
D, 1237, ALL, 0.0,,1321,   7
D, 1238, ALL, 0.0,,1322,   7
D, 1239, ALL, 0.0,,1323,   7
D, 1240, ALL, 0.0,,1324,   7
D, 1241, ALL, 0.0,,1325,   7
D, 1242, ALL, 0.0,,1326,   7
D, 1243, ALL, 0.0,,1327,   7
/COM *****USER RESTRAINT DEFINITION*****
D,   85,  UZ, 0.0
D,   91,  UZ, 0.0
D,  141,  UZ, 0.0
D,  147,  UZ, 0.0
D,  302,  UZ, 0.0
D,  308,  UZ, 0.0
D,  358,  UZ, 0.0
D,  364,  UZ, 0.0
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  949,FX,       1.000
F,  949,FY,       2.000
F,  949,FZ,       3.000
F,  949,MX,       4.000
F,  949,MY,       5.000
F,  949,MZ,       6.000
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F,  945,FX,        7.000
F,  945,FY,        8.000
F,  945,FZ,        9.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 13

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/PREP7
/TITLE test13
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .250
LOCAL, 11, 1,  11.000,   0.0,   0.0
LOCAL, 12, 1,   2.922,   5.000, 0.0
LOCAL, 13, 1,  19.227,   4.750, 0.0
LOCAL, 14, 1,   4.636,  -2.250, 0.0
LOCAL, 15, 1,  17.447,  -2.000, 0.0
CSYS, 0
N,    1,     .000,    1.250,     .000
N,    2,     .000,    1.250,    2.000
N,    3,     .000,    1.250,    2.000
N,    4,     .000,    1.250,    2.500
N,    5,     .000,    1.250,    5.000
N,    6,    1.000,    1.250,     .000
N,    7,    1.000,    1.250,    2.000
N,    8,    1.000,    1.250,    2.000
N,    9,    1.000,    1.250,    2.500
N,   10,    1.000,    1.250,    5.000
N,   11,    1.500,    1.250,     .000
N,   12,    1.500,    1.250,    2.000
N,   13,    1.500,    1.250,    2.000
N,   14,    1.500,    1.250,    2.500
N,   15,    1.500,    1.250,    5.000
N,   16,    1.856,    1.250,     .000
N,   17,    1.856,    1.250,    2.000
N,   18,    1.856,    1.250,    2.000
N,   19,    1.856,    1.250,    2.500
N,   20,    1.856,    1.250,    5.000
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N,   22,    2.211,    1.250,    2.000
N,   23,    2.211,    1.250,    2.000
N,   24,    2.211,    1.250,    2.500
N,   25,    2.211,    1.250,    5.000
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N,   27,    2.567,    1.250,    2.000
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N,   29,    2.567,    1.250,    2.500
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N,   31,    2.922,    1.250,     .000
N,   32,    2.922,    1.250,    2.000
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N,   35,    2.922,    1.250,    5.000
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N,  113,   19.227,    1.000,    2.000
N,  114,   19.227,    1.000,    2.500
N,  115,   19.227,    1.000,    5.000
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N,  122,   21.536,    1.000,    2.000
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N,  127,   22.691,    1.000,    2.000
N,  128,   22.691,    1.000,    2.000
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N,  146,   30.000,    1.000,     .000
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N,  148,   30.000,    1.000,    2.000
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N,  157,   1.000,   -.875,   2.500
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N,  222,  23.112,   -.625,   4.000
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N,  224,  25.000,   -.625,   2.000
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N,  226,  25.000,   -.625,   4.000
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N,  229,  28.000,   -.625,   2.500
N,  230,  28.000,   -.625,   4.000
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CSYS, 11
N,  41,  5.750, 148.243,   .000
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N,  43,  5.750, 148.243,  2.000
N,  44,  5.750, 148.243,  2.500
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N,  53,  5.750, 128.536,  2.000
N,  54,  5.750, 128.536,  2.500
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N,  83,  5.750,  69.414,  2.000
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N,  85,  5.750,  69.414,  5.000
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CSYS, 12
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CSYS, 13
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CSYS, 14
N,  171,    1.375,   54.736,     .000
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N,  173,    1.375,   54.736,    2.500
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CSYS, 15
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N,  200,    1.375,  138.510,    2.000
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N,  205,    1.375,  114.255,    2.500
N,  206,    1.375,  114.255,    4.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,   2,  233,   41,  101,    5, -.1000,  .0000,  .0000
NGEN ,   2,  233,   42,  102,    5, -.1000,  .0000,  .0000
NGEN ,   2,  233,   43,  103,    5, -.1000,  .0000,  .0000
NGEN ,   2,  233,   44,  104,    5, -.1000,  .0000,  .0000
NGEN ,   2,  233,   45,  105,    5, -.1000,  .0000,  .0000
NGEN ,   2,  233,  175,  195,    4, -.1000,  .0000,  .0000
NGEN ,   2,  233,  176,  196,    4, -.1000,  .0000,  .0000
NGEN ,   2,  233,  177,  197,    4, -.1000,  .0000,  .0000
NGEN ,   2,  233,  178,  198,    4, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  231,    1.000,     .000,    2.000
N,  232,    1.500,     .000,    2.500
N,  233,   25.000,     .000,    2.000
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,   1.500
REAL,  1
E,    1,    2,    7,    6
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EGEN,    4,    1,    1,    1,    1
EGEN,   29,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E, 151,  152,  156,  155
EGEN,    3,    1,  117,  117,    1
EGEN,   19,    4,  117,  119,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 274,  41
EGEN,  13,   5, 174, 174,   1
EGEN,   5,   1, 174, 186,   1
E, 408, 175
EGEN,   6,   4, 239, 239,   1
EGEN,   4,   1, 239, 244,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  4,    7.1400,    2.6239,    6.8782,    3.4000,    2.1000,,,    6.7383
REAL,  4
E ,    1,  151
R,  5,     .5600,     .0229,     .0299,     .8000,     .7000,,,     .0538
REAL,  5
E ,  230,  100
R,  6,     .0200,     .0000,     .0001,     .2000,     .1000,,,     .0000
REAL,  6
E ,   25,   35
R,  7,     .1200,     .0009,     .0016,     .4000,     .3000,,,     .0021
REAL,  7
E ,  198,  210
R,  8,     .3000,     .0063,     .0090,     .6000,     .5000,,,     .0147
REAL,  8
E ,  215,  189
R,  9,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  9
E ,   11,   16
E ,   16,   21
E ,   21,   22
E ,   22,   23
E ,   23,   24
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E ,  24,  18
E ,  18,  12
E ,  12,  11
E ,  42,  47
E ,  47,  52
E ,  52,  57
E ,  57,  62
E ,  62,  67
E ,  67,  72
E ,  72,  77
E ,  77,  82
E ,  82,  87
E ,  87,  92
E ,  92,  97
E ,  97,  98
E ,  98,  99
E ,  99, 100
E , 100,  95
E ,  95,  90
E ,  90,  85
E ,  85,  80
E ,  80,  75
E ,  75,  70
E ,  70,  65
E ,  65,  60
E ,  60,  55
E , 120, 119
E , 119, 118
E , 118, 117
E , 117, 116
R, 10,    .1963,    .0031,    .0031,    .5000,    .5000,,,    .0061
REAL, 10
E ,   7, 231
E , 231, 156
R, 11,    .4418,    .0155,    .0155,    .7500,    .7500,,,    .0311
REAL, 11
E ,  14, 232
E , 232, 161
R, 12,    .1963,    .0031,    .0031,    .5000,    .5000,,,    .0061
REAL, 12
E , 138, 233
E , 233, 224
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
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/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  274, ALL, 0.0,, 334,   5
D,  275, ALL, 0.0,, 335,   5
D,  276, ALL, 0.0,, 336,   5
D,  277, ALL, 0.0,, 337,   5
D,  278, ALL, 0.0,, 338,   5
D,  408, ALL, 0.0,, 428,   4
D,  409, ALL, 0.0,, 429,   4
D,  410, ALL, 0.0,, 430,   4
D,  411, ALL, 0.0,, 431,   4
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  233,FX,       1.000
F,  233,FY,       2.000
F,  233,FZ,       3.000
LWRITE
/COM *****LOAD CASE NO.  2*****
FDELE,  233,FX
FDELE,  233,FY
FDELE,  233,FZ
F,  233,FX,       4.000
F,  233,FY,       5.000
F,  233,FZ,       6.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 14

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/PREP7
/TITLE TEST14
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .250
LOCAL, 11, 1,  11.000,   0.0,   0.0
LOCAL, 12, 1,   4.553,   2.000, 0.0
LOCAL, 13, 1,  17.364,   2.250, 0.0
LOCAL, 14, 1,   2.773,  -4.750, 0.0
LOCAL, 15, 1,  19.078,  -5.000, 0.0
CSYS, 0
N,    1,     .000,     .625,    .000
N,    2,     .000,     .625,   2.000
N,    3,     .000,     .625,   2.500
N,    4,     .000,     .625,   4.000
N,    5,    1.000,     .625,    .000
N,    6,    1.000,     .625,   2.000
N,    7,    1.000,     .625,   2.500
N,    8,    1.000,     .625,   4.000
N,    9,    1.500,     .625,    .000
N,   10,    1.500,     .625,   2.000
N,   11,    1.500,     .625,   2.500
N,   12,    1.500,     .625,   4.000
N,   13,    3.027,     .625,    .000
N,   14,    3.027,     .625,   2.000
N,   15,    3.027,     .625,   2.500
N,   16,    3.027,     .625,   4.000
N,   17,    4.553,     .625,    .000
N,   18,    4.553,     .625,   2.000
N,   19,    4.553,     .625,   2.500
N,   20,    4.553,     .625,   4.000
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N,   58,   17.364,     .875,   2.000
N,   59,   17.364,     .875,   2.500
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CSYS, 12
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CSYS, 14
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CSYS, 15
N, 186,    3.750,  119.122,     .000
N, 187,    3.750,  119.122,    2.000
N, 188,    3.750,  119.122,    2.000
N, 189,    3.750,  119.122,    2.500
N, 190,    3.750,  119.122,    5.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  233,   25,   45,    4, -.1000,  .0000,  .0000
NGEN ,    2,  233,   26,   46,    4, -.1000,  .0000,  .0000
NGEN ,    2,  233,   27,   47,    4, -.1000,  .0000,  .0000
NGEN ,    2,  233,   28,   48,    4, -.1000,  .0000,  .0000
NGEN ,    2,  233,  121,  181,    5, -.1000,  .0000,  .0000
NGEN ,    2,  233,  122,  182,    5, -.1000,  .0000,  .0000
NGEN ,    2,  233,  123,  183,    5, -.1000,  .0000,  .0000
NGEN ,    2,  233,  124,  184,    5, -.1000,  .0000,  .0000
NGEN ,    2,  233,  125,  185,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N, 231,    1.000,     .000,    2.000
N, 232,    1.500,     .000,    2.500
N, 233,   25.000,     .000,    2.000
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .750
REAL,  1
E,    1,    2,    6,    5
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EGEN,   3,    1,    1,    1,    1
EGEN,  19,    4,    1,    3,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,   1.500
REAL,  2
E,  81,  82,  87,  86
EGEN,   4,    1,   58,   58,    1
EGEN,  29,    5,   58,   61,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 258,  25
EGEN,   6,   4, 174, 174,   1
EGEN,   4,   1, 174, 179,   1
E, 354, 121
EGEN,  13,   5, 198, 198,   1
EGEN,   5,   1, 198, 210,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  4,    7.1400,   2.6239,   6.8782,   3.4000,   2.1000,,,   6.7383
REAL,  4
E ,  81,   1
R,  5,     .5600,    .0229,    .0299,    .8000,    .7000,,,    .0538
REAL,  5
E ,  80,  230
R,  6,     .0200,    .0000,    .0001,    .2000,    .1000,,,    .0000
REAL,  6
E ,  105,  115
R,  7,     .1200,    .0009,    .0016,    .4000,    .3000,,,    .0021
REAL,  7
E ,  48,   60
R,  8,     .3000,    .0063,    .0090,    .6000,    .5000,,,    .0147
REAL,  8
E ,  65,   39
R,  9, 100.0000, 999.0000, 999.0000,   1.0000,   1.0000,,, 999.0000
REAL,  9
E ,  91,   95
E ,  95,   99
E ,  101,  102
E ,  102,  103
E ,  103,  104
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E ,  104,   98
E ,   98,   92
E ,   92,   91
E ,  122,  127
E ,  127,  132
E ,  132,  137
E ,  137,  142
E ,  142,  147
E ,  147,  152
E ,  152,  157
E ,  157,  162
E ,  162,  167
E ,  167,  172
E ,  172,  177
E ,  177,  178
E ,  178,  179
E ,  179,  180
E ,  180,  175
E ,  175,  170
E ,  170,  165
E ,  165,  160
E ,  160,  155
E ,  155,  150
E ,  150,  145
E ,  145,  140
E ,  140,  135
E ,  200,  199
E ,  199,  198
E ,  198,  197
E ,  197,  196
R,  10,     .1963,    .0031,    .0031,    .5000,    .5000,,,     .0061
REAL,  10
E ,   87,  231
E ,  231,    6
R,  11,     .4418,    .0155,    .0155,    .7500,    .7500,,,     .0311
REAL,  11
E ,   94,  232
E ,  232,   11
R,  12,     .1963,    .0031,    .0031,    .5000,    .5000,,,     .0061
REAL,  12
E ,  168,  233
E ,  233,   74
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
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/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  258, ALL, 0.0,, 278,   4
D,  259, ALL, 0.0,, 279,   4
D,  260, ALL, 0.0,, 280,   4
D,  261, ALL, 0.0,, 281,   4
D,  354, ALL, 0.0,, 414,   5
D,  355, ALL, 0.0,, 415,   5
D,  356, ALL, 0.0,, 416,   5
D,  357, ALL, 0.0,, 417,   5
D,  358, ALL, 0.0,, 418,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  233,FX,        1.000
F,  233,FY,        2.000
F,  233,FZ,        3.000
LWRITE
/COM *****LOAD CASE NO.  2*****
FDELE,  233,FX
FDELE,  233,FY
FDELE,  233,FZ
F,  233,FX,        4.000
F,  233,FY,        5.000
F,  233,FZ,        6.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 15

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/PREP7
/TITLE test15
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .250
LOCAL, 11, 1,  11.000,   0.0,    0.0
LOCAL, 12, 1,   2.922,   5.000, 0.0
LOCAL, 13, 1,  19.227,   4.750, 0.0
LOCAL, 14, 1,   4.636,  -2.250, 0.0
LOCAL, 15, 1,  17.447,  -2.000, 0.0
CSYS, 0
N,    1,     .000,     .500,     .000
N,    2,     .000,     .500,    2.000
N,    3,     .000,     .500,    2.000
N,    4,     .000,     .500,    2.500
N,    5,     .000,     .500,    5.000
N,    6,    1.000,     .500,     .000
N,    7,    1.000,     .500,    2.000
N,    8,    1.000,     .500,    2.000
N,    9,    1.000,     .500,    2.500
N,   10,    1.000,     .500,    5.000
N,   11,    1.500,     .500,     .000
N,   12,    1.500,     .500,    2.000
N,   13,    1.500,     .500,    2.000
N,   14,    1.500,     .500,    2.500
N,   15,    1.500,     .500,    5.000
N,   16,    1.856,     .500,     .000
N,   17,    1.856,     .500,    2.000
N,   18,    1.856,     .500,    2.000
N,   19,    1.856,     .500,    2.500
N,   20,    1.856,     .500,    5.000
N,   21,    2.211,     .500,     .000
N,   22,    2.211,     .500,    2.000
N,   23,    2.211,     .500,    2.000
N,   24,    2.211,     .500,    2.500
N,   25,    2.211,     .500,    5.000
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N,   27,    2.567,     .500,    2.000
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N,  29,   2.567,   .500,  2.500
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N,  34,   2.922,   .500,  2.500
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N, 112,  19.227,   .250,  2.000
N, 113,  19.227,   .250,  2.000
N, 114,  19.227,   .250,  2.500
N, 115,  19.227,   .250,  5.000
N, 116,  20.382,   .250,   .000
N, 117,  20.382,   .250,  2.000
N, 118,  20.382,   .250,  2.000
N, 119,  20.382,   .250,  2.500
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N, 122,  21.536,   .250,  2.000
N, 123,  21.536,   .250,  2.000
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N, 125,  21.536,   .250,  5.000
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N, 127,  22.691,   .250,  2.000
N, 128,  22.691,   .250,  2.000
N, 129,  22.691,   .250,  2.500
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N, 133,  23.845,   .250,  2.000
N, 134,  23.845,   .250,  2.500
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N, 156,  1.000, -.500,  2.000
N, 157,  1.000, -.500,  2.500
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N, 222, 23.112, -.250,  4.000
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N, 226, 25.000, -.250,  4.000
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N, 228, 28.000, -.250,  2.000
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N, 230, 28.000, -.250,  4.000
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CSYS, 11
N,  41,   5.000, 148.243,     .000
N,  42,   5.000, 148.243,    2.000
N,  43,   5.000, 148.243,    2.000
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N,  61,   5.000, 108.829,     .000
N,  62,   5.000, 108.829,    2.000
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N,  187,   5.000,  -74.553,     .000
N,  188,   5.000,  -74.553,    2.000
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N,  192,   5.000,  -45.894,    2.000
N,  193,   5.000,  -45.894,    2.500
N,  194,   5.000,  -45.894,    4.000
N,  195,   5.000,  -17.235,     .000
N,  196,   5.000,  -17.235,    2.000
N,  197,   5.000,  -17.235,    2.500
N,  198,   5.000,  -17.235,    4.000
CSYS, 12
N,   36,   4.500,  -60.878,     .000
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N,   39,    4.500,  -60.878,     2.500
N,   40,    4.500,  -60.878,     5.000
CSYS, 13
N,  106,    4.500, -120.000,      .000
N,  107,    4.500, -120.000,     2.000
N,  108,    4.500, -120.000,     2.000
N,  109,    4.500, -120.000,     2.500
N,  110,    4.500, -120.000,     5.000
CSYS, 14
N,  171,    1.750,   54.736,      .000
N,  172,    1.750,   54.736,     2.000
N,  173,    1.750,   54.736,     2.500
N,  174,    1.750,   54.736,     4.000
CSYS, 15
N,  199,    1.750,  138.510,      .000
N,  200,    1.750,  138.510,     2.000
N,  201,    1.750,  138.510,     2.500
N,  202,    1.750,  138.510,     4.000
N,  203,    1.750,  114.255,      .000
N,  204,    1.750,  114.255,     2.000
N,  205,    1.750,  114.255,     2.500
N,  206,    1.750,  114.255,     4.000
CSYS,  0
NGEN ,    2,  230,    1,   35,     1,  .0000, 1.5000,  .0000
CSYS, 12
NGEN ,    2,  230,   36,   40,     1,-1.5000,  .0000,  .0000
CSYS, 11
NGEN ,    2,  230,   41,  105,     1, 1.5000,  .0000,  .0000
CSYS, 13
NGEN ,    2,  230,  106,  110,     1,-1.5000,  .0000,  .0000
CSYS,  0
NGEN ,    2,  230,  111,  150,     1,  .0000, 1.5000,  .0000
CSYS,  0
NGEN ,    2,  230,  151,  170,     1,  .0000, -.7500,  .0000
CSYS, 14
NGEN ,    2,  230,  171,  174,     1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,    2,  230,  175,  198,     1,  .7500,  .0000,  .0000
CSYS, 15
NGEN ,    2,  230,  199,  220,     1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2,  230,  221,  230,     1,  .0000, -.7500,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
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NGEN ,   2, 463,  41, 101,   5, -.1000, .0000, .0000
NGEN ,   2, 463,  42, 102,   5, -.1000, .0000, .0000
NGEN ,   2, 463,  43, 103,   5, -.1000, .0000, .0000
NGEN ,   2, 463,  44, 104,   5, -.1000, .0000, .0000
NGEN ,   2, 463,  45, 105,   5, -.1000, .0000, .0000
NGEN ,   2, 463, 175, 195,   4, -.1000, .0000, .0000
NGEN ,   2, 463, 176, 196,   4, -.1000, .0000, .0000
NGEN ,   2, 463, 177, 197,   4, -.1000, .0000, .0000
NGEN ,   2, 463, 178, 198,   4, -.1000, .0000, .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS, 0
N, 461,   1.000,    .000,   2.000
N, 462,   1.500,    .000,   2.500
N, 463,  25.000,    .000,   2.000
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,   1,   2,   7,   6, 231, 232, 237, 236
EGEN,   4,   1,   1,   1,   1
EGEN,  29,   5,   1,   4,   1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E, 151, 152, 156, 155, 381, 382, 386, 385
EGEN,   3,   1, 117, 117,   1
EGEN,  19,   4, 117, 119,   1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R, 1, 10.0
REAL, 1
E, 504, 41
EGEN, 13,  5, 174, 174,  1
EGEN,  5,  1, 174, 186,  1
E, 638, 175
EGEN,  6,  4, 239, 239,  1
EGEN,  4,  1, 239, 244,  1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,  2,   7.1400,   2.6239,   6.8782,   3.4000,   2.1000,,,   6.7383
REAL,  2
E , 231, 381
R,  3,    .5600,    .0229,    .0299,    .8000,    .7000,,,    .0538
REAL,  3
E , 460, 330
R,  4,    .0200,    .0000,    .0001,    .2000,    .1000,,,    .0000
REAL,  4
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E ,  255,  265
R,   5,     .1200,     .0009,     .0016,     .4000,     .3000,,,     .0021
REAL,   5
E ,  428,  440
R,   6,     .3000,     .0063,     .0090,     .6000,     .5000,,,     .0147
REAL,   6
E ,  445,  419
R,   7,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,   7
E ,  241,  246
E ,  246,  251
E ,  251,  252
E ,  252,  253
E ,  253,  254
E ,  254,  248
E ,  248,  242
E ,  242,  241
E ,  272,  277
E ,  277,  282
E ,  282,  287
E ,  287,  292
E ,  292,  297
E ,  297,  302
E ,  302,  307
E ,  307,  312
E ,  312,  317
E ,  317,  322
E ,  322,  327
E ,  327,  328
E ,  328,  329
E ,  329,  330
E ,  330,  325
E ,  325,  320
E ,  320,  315
E ,  315,  310
E ,  310,  305
E ,  305,  300
E ,  300,  295
E ,  295,  290
E ,  290,  285
E ,  350,  349
E ,  349,  348
E ,  348,  347
E ,  347,  346
R,   8,     .1963,     .0031,     .0031,     .5000,     .5000,,,     .0061
REAL,   8
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E ,   7,  461
E ,  461,  156
R,   9,    .4418,    .0155,    .0155,    .7500,    .7500,,,    .0311
REAL,  9
E ,  14,  462
E ,  462,  161
R,  10,    .1963,    .0031,    .0031,    .5000,    .5000,,,    .0061
REAL,  10
E ,  138,  463
E ,  463,  224
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  504, ALL, 0.0,, 564,   5
D,  505, ALL, 0.0,, 565,   5
D,  506, ALL, 0.0,, 566,   5
D,  507, ALL, 0.0,, 567,   5
D,  508, ALL, 0.0,, 568,   5
D,  638, ALL, 0.0,, 658,   4
D,  639, ALL, 0.0,, 659,   4
D,  640, ALL, 0.0,, 660,   4
D,  641, ALL, 0.0,, 661,   4
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  463,FX,       1.000
F,  463,FY,       2.000
F,  463,FZ,       3.000
LWRITE
/COM *****LOAD CASE NO.  2*****
FDELE,  463,FX
FDELE,  463,FY
FDELE,  463,FZ
F,  463,FX,       4.000
F,  463,FY,       5.000
F,  463,FZ,       6.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 16

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/PREP7
/TITLE TEST16
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .250
LOCAL, 11, 1,  11.000,   0.0,   0.0
LOCAL, 12, 1,   4.553,   2.000, 0.0
LOCAL, 13, 1,  17.364,   2.250, 0.0
LOCAL, 14, 1,   2.773,  -4.750, 0.0
LOCAL, 15, 1,  19.078,  -5.000, 0.0
CSYS, 0
N,    1,    .000,    .250,    .000
N,    2,    .000,    .250,   2.000
N,    3,    .000,    .250,   2.500
N,    4,    .000,    .250,   4.000
N,    5,   1.000,    .250,    .000
N,    6,   1.000,    .250,   2.000
N,    7,   1.000,    .250,   2.500
N,    8,   1.000,    .250,   4.000
N,    9,   1.500,    .250,    .000
N,   10,   1.500,    .250,   2.000
N,   11,   1.500,    .250,   2.500
N,   12,   1.500,    .250,   4.000
N,   13,   3.027,    .250,    .000
N,   14,   3.027,    .250,   2.000
N,   15,   3.027,    .250,   2.500
N,   16,   3.027,    .250,   4.000
N,   17,   4.553,    .250,    .000
N,   18,   4.553,    .250,   2.000
N,   19,   4.553,    .250,   2.500
N,   20,   4.553,    .250,   4.000
N,   57,  17.364,    .500,    .000
N,   58,  17.364,    .500,   2.000
N,   59,  17.364,    .500,   2.500
N,   60,  17.364,    .500,   4.000
N,   61,  19.273,    .500,    .000
N,   62,  19.273,    .500,   2.000
N,   63,  19.273,    .500,   2.500
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N,	64,	19.273,	.500,	4.000
N,	65,	21.182,	.500,	.000
N,	66,	21.182,	.500,	2.000
N,	67,	21.182,	.500,	2.500
N,	68,	21.182,	.500,	4.000
N,	69,	23.091,	.500,	.000
N,	70,	23.091,	.500,	2.000
N,	71,	23.091,	.500,	2.500
N,	72,	23.091,	.500,	4.000
N,	73,	25.000,	.500,	.000
N,	74,	25.000,	.500,	2.000
N,	75,	25.000,	.500,	2.500
N,	76,	25.000,	.500,	4.000
N,	77,	28.000,	.500,	.000
N,	78,	28.000,	.500,	2.000
N,	79,	28.000,	.500,	2.500
N,	80,	28.000,	.500,	4.000
N,	81,	.000,	-.250,	.000
N,	82,	.000,	-.250,	2.000
N,	83,	.000,	-.250,	2.000
N,	84,	.000,	-.250,	2.500
N,	85,	.000,	-.250,	5.000
N,	86,	1.000,	-.250,	.000
N,	87,	1.000,	-.250,	2.000
N,	88,	1.000,	-.250,	2.000
N,	89,	1.000,	-.250,	2.500
N,	90,	1.000,	-.250,	5.000
N,	91,	1.500,	-.250,	.000
N,	92,	1.500,	-.250,	2.000
N,	93,	1.500,	-.250,	2.000
N,	94,	1.500,	-.250,	2.500
N,	95,	1.500,	-.250,	5.000
N,	96,	1.818,	-.250,	.000
N,	97,	1.818,	-.250,	2.000
N,	98,	1.818,	-.250,	2.000
N,	99,	1.818,	-.250,	2.500
N,	100,	1.818,	-.250,	5.000
N,	101,	2.136,	-.250,	.000
N,	102,	2.136,	-.250,	2.000
N,	103,	2.136,	-.250,	2.000
N,	104,	2.136,	-.250,	2.500
N,	105,	2.136,	-.250,	5.000
N,	106,	2.455,	-.250,	.000
N,	107,	2.455,	-.250,	2.000
N,	108,	2.455,	-.250,	2.000
N,	109,	2.455,	-.250,	2.500

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N, 110, 2.455, -.250, 5.000
N, 111, 2.773, -.250, .000
N, 112, 2.773, -.250, 2.000
N, 113, 2.773, -.250, 2.000
N, 114, 2.773, -.250, 2.500
N, 115, 2.773, -.250, 5.000
N, 191, 19.078, -.500, .000
N, 192, 19.078, -.500, 2.000
N, 193, 19.078, -.500, 2.000
N, 194, 19.078, -.500, 2.500
N, 195, 19.078, -.500, 5.000
N, 196, 20.638, -.500, .000
N, 197, 20.638, -.500, 2.000
N, 198, 20.638, -.500, 2.000
N, 199, 20.638, -.500, 2.500
N, 200, 20.638, -.500, 5.000
N, 201, 22.198, -.500, .000
N, 202, 22.198, -.500, 2.000
N, 203, 22.198, -.500, 2.000
N, 204, 22.198, -.500, 2.500
N, 205, 22.198, -.500, 5.000
N, 206, 23.759, -.500, .000
N, 207, 23.759, -.500, 2.000
N, 208, 23.759, -.500, 2.000
N, 209, 23.759, -.500, 2.500
N, 210, 23.759, -.500, 5.000
N, 211, 25.319, -.500, .000
N, 212, 25.319, -.500, 2.000
N, 213, 25.319, -.500, 2.000
N, 214, 25.319, -.500, 2.500
N, 215, 25.319, -.500, 5.000
N, 216, 26.879, -.500, .000
N, 217, 26.879, -.500, 2.000
N, 218, 26.879, -.500, 2.000
N, 219, 26.879, -.500, 2.500
N, 220, 26.879, -.500, 5.000
N, 221, 28.440, -.500, .000
N, 222, 28.440, -.500, 2.000
N, 223, 28.440, -.500, 2.000
N, 224, 28.440, -.500, 2.500
N, 225, 28.440, -.500, 5.000
N, 226, 30.000, -.500, .000
N, 227, 30.000, -.500, 2.000
N, 228, 30.000, -.500, 2.000
N, 229, 30.000, -.500, 2.500
N, 230, 30.000, -.500, 5.000
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CSYS, 11
N,  25,   5.000,  162.765,    .000
N,  26,   5.000,  162.765,   2.000
N,  27,   5.000,  162.765,   2.500
N,  28,   5.000,  162.765,   4.000
N,  29,   5.000,  134.106,    .000
N,  30,   5.000,  134.106,   2.000
N,  31,   5.000,  134.106,   2.500
N,  32,   5.000,  134.106,   4.000
N,  33,   5.000,  105.447,    .000
N,  34,   5.000,  105.447,   2.000
N,  35,   5.000,  105.447,   2.500
N,  36,   5.000,  105.447,   4.000
N,  37,   5.000,   76.789,    .000
N,  38,   5.000,   76.789,   2.000
N,  39,   5.000,   76.789,   2.500
N,  40,   5.000,   76.789,   4.000
N,  41,   5.000,   48.130,    .000
N,  42,   5.000,   48.130,   2.000
N,  43,   5.000,   48.130,   2.500
N,  44,   5.000,   48.130,   4.000
N,  45,   5.000,   19.471,    .000
N,  46,   5.000,   19.471,   2.000
N,  47,   5.000,   19.471,   2.500
N,  48,   5.000,   19.471,   4.000
N, 121,   5.000, -150.000,    .000
N, 122,   5.000, -150.000,   2.000
N, 123,   5.000, -150.000,   2.000
N, 124,   5.000, -150.000,   2.500
N, 125,   5.000, -150.000,   5.000
N, 126,   5.000, -130.555,    .000
N, 127,   5.000, -130.555,   2.000
N, 128,   5.000, -130.555,   2.000
N, 129,   5.000, -130.555,   2.500
N, 130,   5.000, -130.555,   5.000
N, 131,   5.000, -111.111,    .000
N, 132,   5.000, -111.111,   2.000
N, 133,   5.000, -111.111,   2.000
N, 134,   5.000, -111.111,   2.500
N, 135,   5.000, -111.111,   5.000
N, 136,   5.000,  -91.667,    .000
N, 137,   5.000,  -91.667,   2.000
N, 138,   5.000,  -91.667,   2.000
N, 139,   5.000,  -91.667,   2.500
N, 140,   5.000,  -91.667,   5.000
N, 141,   5.000,  -72.222,    .000
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N, 142,   5.000, -72.222,   2.000
N, 143,   5.000, -72.222,   2.000
N, 144,   5.000, -72.222,   2.500
N, 145,   5.000, -72.222,   5.000
N, 146,   5.000, -52.778,    .000
N, 147,   5.000, -52.778,   2.000
N, 148,   5.000, -52.778,   2.000
N, 149,   5.000, -52.778,   2.500
N, 150,   5.000, -52.778,   5.000
N, 151,   5.000, -33.333,    .000
N, 152,   5.000, -33.333,   2.000
N, 153,   5.000, -33.333,   2.000
N, 154,   5.000, -33.333,   2.500
N, 155,   5.000, -33.333,   5.000
N, 156,   5.000, -13.889,    .000
N, 157,   5.000, -13.889,   2.000
N, 158,   5.000, -13.889,   2.000
N, 159,   5.000, -13.889,   2.500
N, 160,   5.000, -13.889,   5.000
N, 161,   5.000,   5.556,    .000
N, 162,   5.000,   5.556,   2.000
N, 163,   5.000,   5.556,   2.000
N, 164,   5.000,   5.556,   2.500
N, 165,   5.000,   5.556,   5.000
N, 166,   5.000,  25.000,    .000
N, 167,   5.000,  25.000,   2.000
N, 168,   5.000,  25.000,   2.000
N, 169,   5.000,  25.000,   2.500
N, 170,   5.000,  25.000,   5.000
N, 171,   5.000,   6.081,    .000
N, 172,   5.000,   6.081,   2.000
N, 173,   5.000,   6.081,   2.000
N, 174,   5.000,   6.081,   2.500
N, 175,   5.000,   6.081,   5.000
N, 176,   5.000, -12.838,    .000
N, 177,   5.000, -12.838,   2.000
N, 178,   5.000, -12.838,   2.000
N, 179,   5.000, -12.838,   2.500
N, 180,   5.000, -12.838,   5.000
N, 181,   5.000, -31.757,    .000
N, 182,   5.000, -31.757,   2.000
N, 183,   5.000, -31.757,   2.000
N, 184,   5.000, -31.757,   2.500
N, 185,   5.000, -31.757,   5.000
CSYS, 12
N,  21,   1.750, -53.618,    .000
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N,  22,   1.750,  -53.618,   2.000
N,  23,   1.750,  -53.618,   2.500
N,  24,   1.750,  -53.618,   4.000
CSYS, 13
N,  49,   1.750, -137.019,    .000
N,  50,   1.750, -137.019,   2.000
N,  51,   1.750, -137.019,   2.500
N,  52,   1.750, -137.019,   4.000
N,  53,   1.750, -113.510,    .000
N,  54,   1.750, -113.510,   2.000
N,  55,   1.750, -113.510,   2.500
N,  56,   1.750, -113.510,   4.000
CSYS, 14
N, 116,   4.500,   60.000,    .000
N, 117,   4.500,   60.000,   2.000
N, 118,   4.500,   60.000,   2.000
N, 119,   4.500,   60.000,   2.500
N, 120,   4.500,   60.000,   5.000
CSYS, 15
N, 186,   4.500,  119.122,    .000
N, 187,   4.500,  119.122,   2.000
N, 188,   4.500,  119.122,   2.000
N, 189,   4.500,  119.122,   2.500
N, 190,   4.500,  119.122,   5.000
CSYS,  0
NGEN ,   2, 230,   1,  20,   1, .0000,  .7500,  .0000
CSYS, 12
NGEN ,   2, 230,  21,  24,   1, -.7500, .0000,  .0000
CSYS, 11
NGEN ,   2, 230,  25,  48,   1, .7500,  .0000,  .0000
CSYS, 13
NGEN ,   2, 230,  49,  56,   1, -.7500, .0000,  .0000
CSYS,  0
NGEN ,   2, 230,  57,  80,   1, .0000,  .7500,  .0000
CSYS,  0
NGEN ,   2, 230,  81, 115,   1, .0000,-1.5000,  .0000
CSYS, 14
NGEN ,   2, 230, 116, 120,   1,-1.5000, .0000,  .0000
CSYS, 11
NGEN ,   2, 230, 121, 185,   1, 1.5000, .0000,  .0000
CSYS, 15
NGEN ,   2, 230, 186, 168,   1,-1.5000, .0000,  .0000
CSYS,  0
NGEN ,   2, 230, 169, 230,   1, .0000,-1.5000,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
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NGEN ,   2, 463,  25,  45,   4, -.1000, .0000, .0000
NGEN ,   2, 463,  26,  46,   4, -.1000, .0000, .0000
NGEN ,   2, 463,  27,  47,   4, -.1000, .0000, .0000
NGEN ,   2, 463,  28,  48,   4, -.1000, .0000, .0000
NGEN ,   2, 463, 121, 181,   5, -.1000, .0000, .0000
NGEN ,   2, 463, 122, 182,   5, -.1000, .0000, .0000
NGEN ,   2, 463, 123, 183,   5, -.1000, .0000, .0000
NGEN ,   2, 463, 124, 184,   5, -.1000, .0000, .0000
NGEN ,   2, 463, 125, 185,   5, -.1000, .0000, .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS, 0
N, 461,   1.000,    .000,   2.000
N, 462,   1.500,    .000,   2.500
N, 463,  25.000,    .000,   2.000
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,   1,   2,   6,   5, 231, 232, 236, 235
EGEN,   3,   1,   1,   1,   1
EGEN,  19,   4,   1,   3,   1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E,  81,  82,  87,  86, 311, 312, 317, 316
EGEN,   4,   1,  58,  58,   1
EGEN,  29,   5,  58,  61,   1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R, 1, 10.0
REAL, 1
E, 488, 25
EGEN,  6,  4, 174, 174,  1
EGEN,  4,  1, 174, 179,  1
E, 584, 121
EGEN, 13,  5, 198, 198,  1
EGEN,  5,  1, 198, 210,  1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R, 2,   7.1400,   2.6239,   6.8782,   3.4000,   2.1000,,,   6.7383
REAL,  2
E , 311, 231
R, 3,    .5600,    .0229,    .0299,    .8000,    .7000,,,    .0538
REAL,  3
E , 310, 460
R, 4,    .0200,    .0000,    .0001,    .2000,    .1000,,,    .0000
REAL,  4
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E , 335, 345
R, 5, .1200, .0009, .0016, .4000, .3000,,, .0021
REAL, 5
E , 278, 290
R, 6, .3000, .0063, .0090, .6000, .5000,,, .0147
REAL, 6
E , 295, 269
R, 7, 100.0000, 999.0000, 999.0000, 1.0000, 1.0000,,, 999.0000
REAL, 7
E , 321, 325
E , 325, 329
E , 331, 332
E , 332, 333
E , 333, 334
E , 334, 328
E , 328, 322
E , 322, 321
E , 352, 357
E , 357, 362
E , 362, 367
E , 367, 372
E , 372, 377
E , 377, 382
E , 382, 387
E , 387, 392
E , 392, 397
E , 397, 402
E , 402, 407
E , 407, 408
E , 408, 409
E , 409, 410
E , 410, 405
E , 405, 400
E , 400, 395
E , 395, 390
E , 390, 385
E , 385, 380
E , 380, 375
E , 375, 370
E , 370, 365
E , 430, 429
E , 429, 428
E , 428, 427
E , 427, 426
R, 8, .1963, .0031, .0031, .5000, .5000,,, .0061
REAL, 8
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E ,  87, 461
E , 461,   6
R,  9,    .4418,    .0155,    .0155,    .7500,    .7500,,,    .0311
REAL,  9
E ,  94, 462
E , 462,  11
R, 10,    .1963,    .0031,    .0031,    .5000,    .5000,,,    .0061
REAL, 10
E , 168, 463
E , 463,  74
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D, 488, ALL, 0.0,, 508,  4
D, 489, ALL, 0.0,, 509,  4
D, 490, ALL, 0.0,, 510,  4
D, 491, ALL, 0.0,, 511,  4
D, 584, ALL, 0.0,, 644,  5
D, 585, ALL, 0.0,, 645,  5
D, 586, ALL, 0.0,, 646,  5
D, 587, ALL, 0.0,, 647,  5
D, 588, ALL, 0.0,, 648,  5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F, 463,FX,      1.000
F, 463,FY,      2.000
F, 463,FZ,      3.000
LWRITE
/COM *****LOAD CASE NO.  2*****
FDELE, 463,FX
FDELE, 463,FY
FDELE, 463,FZ
F, 463,FX,      4.000
F, 463,FY,      5.000
F, 463,FZ,      6.000
LWRITE
AFWRITE,, 1
/SHOW,, 1104
```

Validation Problem No. 17

```
/PREP7
/TITLE TEST17
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,      30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.320,   2.588, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.320,  -2.588, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,   1,     .000,   1.212,    .000
N,   2,     .000,   1.212,   1.500
N,   3,     .000,   1.212,   1.500
N,   4,     .000,   1.212,   2.800
N,   5,     .000,   1.212,   3.000
N,   6,    1.625,   1.212,    .000
N,   7,    1.625,   1.212,   1.500
N,   8,    1.625,   1.212,   1.500
N,   9,    1.625,   1.212,   2.800
N,  10,    1.625,   1.212,   3.000
N,  11,    2.500,   1.212,    .000
N,  12,    2.500,   1.212,   1.500
N,  13,    2.250,   1.212,   1.750
N,  14,    2.000,   1.212,   2.800
N,  15,    2.000,   1.212,   3.000
N,  16,    3.000,   1.212,    .000
N,  17,    3.000,   1.212,   1.500
N,  18,    3.000,   1.212,   2.000
N,  19,    3.000,   1.212,   2.800
N,  20,    3.000,   1.212,   3.000
N,  21,    3.320,   1.212,    .000
N,  22,    3.320,   1.212,   1.500
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N,  25,    3.320,   1.212,   3.000
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N,  77,   18.060,    .813,   1.500
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N,	78,	18.060,	.813,	1.077
N,	79,	18.060,	.813,	2.800
N,	80,	18.060,	.813,	3.000
N,	81,	18.000,	.813,	.000
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N,	83,	18.000,	.813,	1.000
N,	84,	18.000,	.813,	2.800
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N,	88,	18.813,	.813,	1.250
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N,	93,	19.625,	.813,	1.500
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N,	123,	3.320,	-1.212,	1.500

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N,  200,  21.500,   -.813,   3.000
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N,   32,   6.375, 160.496,   1.500
N,   33,   6.375, 160.496,   1.769
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N,   48,   6.375,  98.738,   1.538
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N,	134,	6.375,	-160.496,	2.250
N,	135,	6.375,	-160.496,	3.000
N,	136,	6.375,	-139.910,	.000
N,	137,	6.375,	-139.910,	.750
N,	138,	6.375,	-139.910,	1.500
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N,	140,	6.375,	-139.910,	3.000
N,	141,	6.375,	-119.324,	.000
N,	142,	6.375,	-119.324,	.750
N,	143,	6.375,	-119.324,	1.500
N,	144,	6.375,	-119.324,	2.250
N,	145,	6.375,	-119.324,	3.000
N,	146,	6.375,	-98.738,	.000
N,	147,	6.375,	-98.738,	.750
N,	148,	6.375,	-98.738,	1.500
N,	149,	6.375,	-98.738,	2.250
N,	150,	6.375,	-98.738,	3.000
N,	151,	6.375,	-78.153,	.000
N,	152,	6.375,	-78.153,	.750
N,	153,	6.375,	-78.153,	1.500
N,	154,	6.375,	-78.153,	2.250

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N,  155,   6.375,  -78.153,   3.000
N,  156,   6.375,  -57.567,    .000
N,  157,   6.375,  -57.567,    .750
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N,  163,   6.375,  -36.981,   1.500
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N,  170,   6.375,  -16.395,   3.000
CSYS, 12
N,   26,   1.375,  -54.752,    .000
N,   27,   1.375,  -54.752,   1.500
N,   28,   1.375,  -54.752,   1.846
N,   29,   1.375,  -54.752,   2.800
N,   30,   1.375,  -54.752,   3.000
CSYS, 13
N,   71,   1.375, -126.802,    .000
N,   72,   1.375, -126.802,   1.500
N,   73,   1.375, -126.802,   1.154
N,   74,   1.375, -126.802,   2.800
N,   75,   1.375, -126.802,   3.000
CSYS, 14
N,  126,   1.375,   54.752,    .000
N,  127,   1.375,   54.752,    .750
N,  128,   1.375,   54.752,   1.500
N,  129,   1.375,   54.752,   2.250
N,  130,   1.375,   54.752,   3.000
CSYS, 15
N,  171,   1.375,  126.802,    .000
N,  172,   1.375,  126.802,    .750
N,  173,   1.375,  126.802,   1.500
N,  174,   1.375,  126.802,   2.250
N,  175,   1.375,  126.802,   3.000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  203,   31,   66,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,   32,   67,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,   33,   68,    5, -.1000,  .0000,  .0000
NGEN ,    2,  203,   34,   69,    5, -.1000,  .0000,  .0000
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NGEN ,    2, 203,   35,   70,    5, -.1000,  .0000,  .0000
NGEN ,    2, 203,  131,  166,    5, -.1000,  .0000,  .0000
NGEN ,    2, 203,  132,  167,    5, -.1000,  .0000,  .0000
NGEN ,    2, 203,  133,  168,    5, -.1000,  .0000,  .0000
NGEN ,    2, 203,  134,  169,    5, -.1000,  .0000,  .0000
NGEN ,    2, 203,  135,  170,    5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  201,    1.625,     .000,    1.500
N,  202,   19.625,     .000,    1.500
N,  203,    5.461,    4.347,    1.692
/COM *****CLAMP BODY SIDE 1 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 1,    .750
REAL,  1
E,    1,    2,    7,    6
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 QUAD ELEMENTS*****
TYPE, 2
MAT, 1
R, 2,    .750
REAL,  2
E, 101,  102,  107,  106
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  3, 10.0
REAL,  3
E, 234,  31
EGEN,   8,    5, 153, 153,    1
EGEN,   5,    1, 153, 160,    1
E, 334, 131
EGEN,   8,    5, 193, 193,    1
EGEN,   5,    1, 193, 200,    1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   4,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,   4
E ,   38,   43
R,   5,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,   5
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E ,   8,  201
E ,  201,  108
E ,   93,  202
E ,  202,  193
R,   6,  100.0000,  999.0000,  999.0000,     1.0000,     1.0000,,,  999.0000
REAL,   6
E ,   38,  203
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  234, ALL, 0.0,, 269,   5
D,  235, ALL, 0.0,, 270,   5
D,  236, ALL, 0.0,, 271,   5
D,  237, ALL, 0.0,, 272,   5
D,  238, ALL, 0.0,, 273,   5
D,  334, ALL, 0.0,, 369,   5
D,  335, ALL, 0.0,, 370,   5
D,  336, ALL, 0.0,, 371,   5
D,  337, ALL, 0.0,, 372,   5
D,  338, ALL, 0.0,, 373,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  203,FX,       1.111
F,  203,FY,       2.222
F,  203,FZ,       3.333
F,  203,MX,       4.444
F,  203,MY,       5.555
F,  203,MZ,       6.666
LWRITE
AFWRITE,, 1
/SHOW,, 1104
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Validation Problem No. 18

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/PREP7
/TITLE TEST18
KAN, 0
RSIZE, 40
ET, 1, 45
ET, 2, 63
ET, 3, 4
ET, 4, 52
EX, 1,     30000.000
NUXY, 1,  .300
MU, 2,  .000
LOCAL, 11, 1,  10.625,   0.0,   0.0
LOCAL, 12, 1,   3.320,   2.588, 0.0
LOCAL, 13, 1,  18.060,   2.188, 0.0
LOCAL, 14, 1,   3.320,  -2.588, 0.0
LOCAL, 15, 1,  18.060,  -2.188, 0.0
CSYS, 0
N,    1,     .000,     .837,     .000
N,    2,     .000,     .837,    1.500
N,    3,     .000,     .837,    1.500
N,    4,     .000,     .837,    2.800
N,    5,     .000,     .837,    3.000
N,    6,    1.625,     .837,     .000
N,    7,    1.625,     .837,    1.500
N,    8,    1.625,     .837,    1.500
N,    9,    1.625,     .837,    2.800
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N,   14,    2.000,     .837,    2.800
N,   15,    2.000,     .837,    3.000
N,   16,    3.000,     .837,     .000
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N,	94,	19.625,	.438,	2.800
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N,	121,	3.320,	-.837,	.000
N,	122,	3.320,	-.837,	.750
N,	123,	3.320,	-.837,	1.500

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N,	69,	6.000,	16.395,	2.800
N,	70,	6.000,	16.395,	3.000
N,	131,	6.000,	-160.496,	.000
N,	132,	6.000,	-160.496,	.750
N,	133,	6.000,	-160.496,	1.500
N,	134,	6.000,	-160.496,	2.250
N,	135,	6.000,	-160.496,	3.000
N,	136,	6.000,	-139.910,	.000
N,	137,	6.000,	-139.910,	.750
N,	138,	6.000,	-139.910,	1.500
N,	139,	6.000,	-139.910,	2.250
N,	140,	6.000,	-139.910,	3.000
N,	141,	6.000,	-119.324,	.000
N,	142,	6.000,	-119.324,	.750
N,	143,	6.000,	-119.324,	1.500
N,	144,	6.000,	-119.324,	2.250
N,	145,	6.000,	-119.324,	3.000
N,	146,	6.000,	-98.738,	.000
N,	147,	6.000,	-98.738,	.750
N,	148,	6.000,	-98.738,	1.500
N,	149,	6.000,	-98.738,	2.250
N,	150,	6.000,	-98.738,	3.000
N,	151,	6.000,	-78.153,	.000
N,	152,	6.000,	-78.153,	.750
N,	153,	6.000,	-78.153,	1.500
N,	154,	6.000,	-78.153,	2.250

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N,  49,   6.000,   98.738,   2.800
N,  50,   6.000,   98.738,   3.000
N,  51,   6.000,   78.153,    .000
N,  52,   6.000,   78.153,   1.500
N,  53,   6.000,   78.153,   1.462
N,  54,   6.000,   78.153,   2.800
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N,  57,   6.000,   57.567,   1.500
N,  58,   6.000,   57.567,   1.385
N,  59,   6.000,   57.567,   2.800
N,  60,   6.000,   57.567,   3.000
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N,  64,   6.000,   36.981,   2.800
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N,  68,   6.000,   16.395,   1.231
N,  69,   6.000,   16.395,   2.800
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N, 137,   6.000, -139.910,    .750
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N, 142,   6.000, -119.324,    .750
N, 143,   6.000, -119.324,   1.500
N, 144,   6.000, -119.324,   2.250
N, 145,   6.000, -119.324,   3.000
N, 146,   6.000,  -98.738,    .000
N, 147,   6.000,  -98.738,    .750
N, 148,   6.000,  -98.738,   1.500
N, 149,   6.000,  -98.738,   2.250
N, 150,   6.000,  -98.738,   3.000
N, 151,   6.000,  -78.153,    .000
N, 152,   6.000,  -78.153,    .750
N, 153,   6.000,  -78.153,   1.500
N, 154,   6.000,  -78.153,   2.250
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N,  156,    6.000,  -57.567,     .000
N,  157,    6.000,  -57.567,     .750
N,  158,    6.000,  -57.567,    1.500
N,  159,    6.000,  -57.567,    2.250
N,  160,    6.000,  -57.567,    3.000
N,  161,    6.000,  -36.981,     .000
N,  162,    6.000,  -36.981,     .750
N,  163,    6.000,  -36.981,    1.500
N,  164,    6.000,  -36.981,    2.250
N,  165,    6.000,  -36.981,    3.000
N,  166,    6.000,  -16.395,     .000
N,  167,    6.000,  -16.395,     .750
N,  168,    6.000,  -16.395,    1.500
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N,  170,    6.000,  -16.395,    3.000
CSYS, 12
N,   26,    1.750,  -54.752,     .000
N,   27,    1.750,  -54.752,    1.500
N,   28,    1.750,  -54.752,    1.846
N,   29,    1.750,  -54.752,    2.800
N,   30,    1.750,  -54.752,    3.000
CSYS, 13
N,   71,    1.750, -126.802,     .000
N,   72,    1.750, -126.802,    1.500
N,   73,    1.750, -126.802,    1.154
N,   74,    1.750, -126.802,    2.800
N,   75,    1.750, -126.802,    3.000
CSYS, 14
N,  126,    1.750,   54.752,     .000
N,  127,    1.750,   54.752,     .750
N,  128,    1.750,   54.752,    1.500
N,  129,    1.750,   54.752,    2.250
N,  130,    1.750,   54.752,    3.000
CSYS, 15
N,  171,    1.750,  126.802,     .000
N,  172,    1.750,  126.802,     .750
N,  173,    1.750,  126.802,    1.500
N,  174,    1.750,  126.802,    2.250
N,  175,    1.750,  126.802,    3.000
CSYS,  0
NGEN ,     2,  200,     1,   25,     1,  .0000,  .7500,  .0000
CSYS, 12
NGEN ,     2,  200,    26,   30,     1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,     2,  200,    31,   70,     1,  .7500,  .0000,  .0000
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CSYS, 13
NGEN ,    2,  200,    71,    75,     1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2,  200,    76,   100,     1,  .0000,  .7500,  .0000
CSYS,  0
NGEN ,    2,  200,   101,   125,     1,  .0000, -.7500,  .0000
CSYS, 14
NGEN ,    2,  200,   126,   130,     1, -.7500,  .0000,  .0000
CSYS, 11
NGEN ,    2,  200,   131,   170,     1,  .7500,  .0000,  .0000
CSYS, 15
NGEN ,    2,  200,   171,   175,     1, -.7500,  .0000,  .0000
CSYS,  0
NGEN ,    2,  200,   176,   200,     1,  .0000, -.7500,  .0000
/COM *****GAP FOUNDATION NODES*****
CSYS, 11
NGEN ,    2,  403,    31,    66,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,    32,    67,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,    33,    68,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,    34,    69,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,    35,    70,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,   131,   166,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,   132,   167,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,   133,   168,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,   134,   169,     5, -.1000,  .0000,  .0000
NGEN ,    2,  403,   135,   170,     5, -.1000,  .0000,  .0000
/COM *****BOLT, LOAD POINTS, AND ATTACHMENT NODES*****
CSYS,  0
N,  401,     1.625,      .000,     1.500
N,  402,    19.625,      .000,     1.500
N,  403,     5.461,     4.347,     1.692
/COM *****CLAMP BODY SIDE 1 BRICK ELEMENTS*****
TYPE, 1
E,    1,    2,    7,    6,  201,  202,  207,  206
EGEN,    4,    1,    1,    1,    1
EGEN,   19,    5,    1,    4,    1
/COM *****CLAMP BODY SIDE 2 BRICK ELEMENTS*****
TYPE, 1
E,  101,  102,  107,  106,  301,  302,  307,  306
EGEN,    4,    1,   77,   77,    1
EGEN,   19,    5,   77,   80,    1
/COM *****GAP SPRING ELEMENTS*****
TYPE, 4
MAT, 2
R,  1, 10.0
REAL,  1
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E, 434,  31
EGEN,  8,   5, 153, 153,   1
EGEN,  5,   1, 153, 160,   1
E, 534, 131
EGEN,  8,   5, 193, 193,   1
EGEN,  5,   1, 193, 200,   1
/COM *****BEAM AND BOLT MEMBERS*****
TYPE, 3
MAT, 1
R,   2,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  2
E ,  238,  243
R,   3,    1.7671,     .2485,     .2485,    1.5000,    1.5000,,,     .4970
REAL,  3
E ,    8,  401
E ,  401,  108
E ,   93,  402
E ,  402,  193
R,   4,  100.0000,  999.0000,  999.0000,    1.0000,    1.0000,,,  999.0000
REAL,  4
E ,  238,  403
LOADS
CSYS, 0
ITER, -20, 20, 20
KRF, 1
/COM *****GAP FOUNDATION RESTRAINT DEFINITION*****
D,  434, ALL, 0.0,, 469,   5
D,  435, ALL, 0.0,, 470,   5
D,  436, ALL, 0.0,, 471,   5
D,  437, ALL, 0.0,, 472,   5
D,  438, ALL, 0.0,, 473,   5
D,  534, ALL, 0.0,, 569,   5
D,  535, ALL, 0.0,, 570,   5
D,  536, ALL, 0.0,, 571,   5
D,  537, ALL, 0.0,, 572,   5
D,  538, ALL, 0.0,, 573,   5
WSTART, 1, 2
WAVES
/COM *****LOAD CASE NO.  1*****
F,  403,FX,       1.111
F,  403,FY,       2.222
F,  403,FZ,       3.333
F,  403,MX,       4.444
F,  403,MY,       5.555
F,  403,MZ,       6.666
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LWRITE
AFWRITE,, 1
/SHOW,, 1104
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